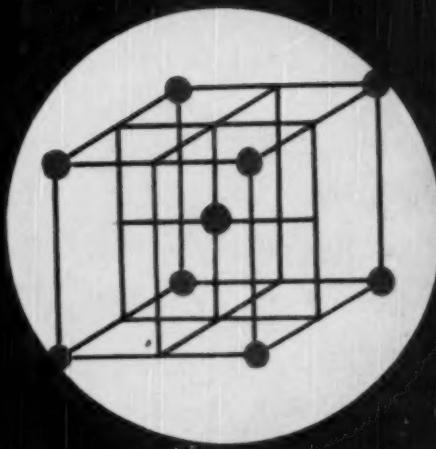


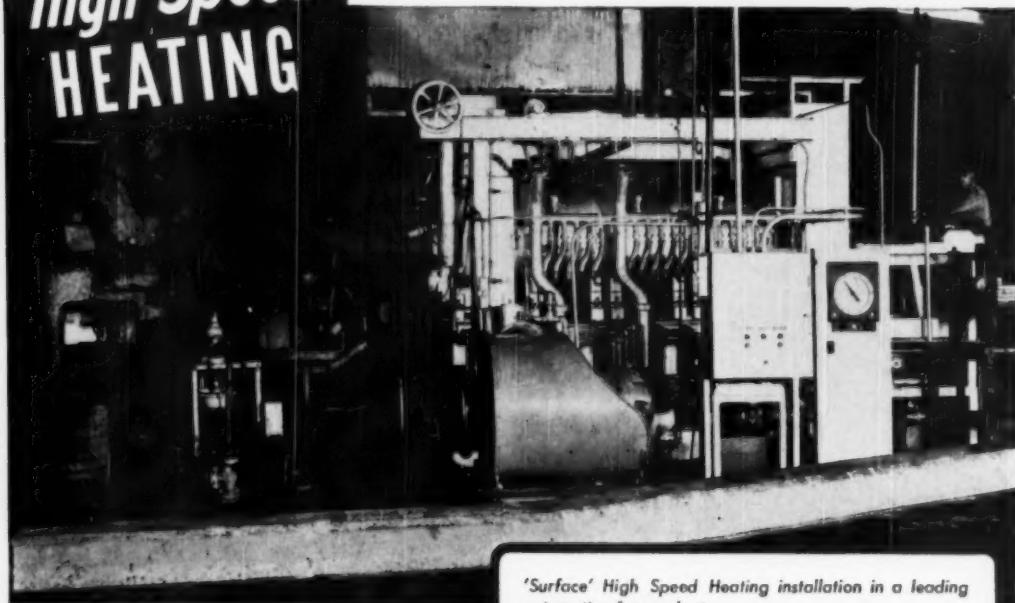
Metal Progress



NOVEMBER 1950

'Surface'
High Speed
HEATING

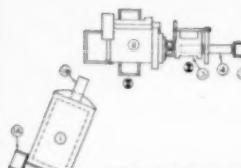
for Production Forging



'Surface' High Speed Heating Furnaces have been making performance records wherever they have been installed in leading production forging plants. Increased production . . . better quality of product and work . . . improved working conditions, all without added floor space, combine to make these furnaces the choice over other heating methods.

Now, you can create New Profits in Production Forging by converting to 'Surface' High Speed Heating. More descriptive data on the high speed combustion system, the furnace unit, application and comparative costs are available in 'Surface' Bulletin SC-144. Write for your copy—today!

'Surface' High Speed Heating installation in a leading automotive forge plant.



PERFORMANCE DATA

PART: Steering knuckle support.
RATED CAPACITY OF FURNACE:
300 Billets (17 lbs. ea.)
SIZE 19" x 2 1/4" x 1 1/4"
REMARKS—
Die life increased 16%
Scrap loss less than 2%
Maintenance less than \$30/ton
FURNACE: Automatic pusher type equipped with dampers for atmosphere control.

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

Stain & Roubaix, Paris FOREIGN AFFILIATES: British Furnaces, Ltd., Chesterfield

'Surface' INDUSTRIAL FURNACES

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging, Gas Atmosphere Generators.

THIS ISSUE



Strategic Metal

691

columbium must be conserved

More than 50 metallurgists in chemical, petroleum, aircraft engine and other consuming industries recount successes and failures with 18-8 stabilized with titanium rather than columbium

Titanium

716

the glamorous light metal

Shop methods for casting and forging . . . Mortar base plates and jet engine disks now in production

Steel Supplies

721

will reflect iron ore shortages

Campbell Memorial Lecturer discusses practicable methods of increasing ore supplies and blast furnace productivity

Nodular Iron

729

malleable as-cast, without an anneal

Basic lined cupola can make the excessively low sulphur iron required for nodular castings. Wide future predicted for a variety of allied products

Metallography

new methods for new metals

Zirconium: p. 709 . . . Films on aluminum: front cover and p. 713 . . . Intensification of contrast: p. 725 . . . Notes on etching methods: p. 732

Complete Table of Contents on p. 689

Flip
the Flap→

As I was saying—

THIS MONTH I'll tell you about "Two Wonderful Guys". So here goes . . .

I am one of those guys (not the guys I am writing about) who puts a mortgage on his farm so that he could have free enterprise and do just as Mrs. Bill wanted him to do and that was to purchase seats for "South Pacific". It would have been less expensive to have purchased tickets *to*, rather than *for*, the South Pacific! However, we felt fully repaid (although the mortgage isn't) and I enjoyed particularly seeing gorgeous Mary Martin "Wash That Man Right Out of Her Hair". But Bill kept remembering and humming Mary's other hit song, "I'm in Love with a Wonderful Guy"—and Bill meant Ezio Pinza (not me).

But I am one up on her because as I was saying, I know *two* wonderful guys. One of them comes by the title "Guy" naturally (it's his given name) and the other guy had to work hard and magnificently to acquire the title.

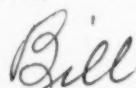
It's Guy Wainwright in the post position, president of Diamond Chain Co., Indianapolis, and it's Arthur Focke, his chief metallurgist, and the immediate past president of Θ , who constitute the "great guy" twosome.

Art has given himself to the Society. He served four years on the Board of Trustees in preparation for the presidency and when his year came he entered into it with a vim and vigor that had the Secretary out of breath most of the time in his effort to keep up. Visiting 50 chapters in one year is a Herculean undertaking and all are happy that Art crossed the finish line with health unimpaired. Art left an imprint on every chapter before which he appeared. His counsel at the various local Executive Committee meetings sprang from his experiences as a chapter officer and a teacher and an educational director. He proved to thousands that he was a wonderful guy.

The other Guy fits right into the picture. He made it possible for Art to devote the tremendous amount of time to do a fine job. Guy has been an ASMember for over 30 years—joining soon after his return from metallurgical studies abroad. He is an example of a metallurgical engineer going to the top and a top executive who is glad to provide the time so that Art could serve the twenty thousand members of the Θ .

So many thanks to both of you from all of the Society. Yes, indeed, a great pair and "Two Wonderful Guys"!

Cordially,



W. H. EISENMAN, *Secretary*
American Society for Metals

BUILD YOUR MARKETS IN THE WEST

WITH THE

Once again, western industry is on the march!

Now — when it is most essential to greater production — comes the timely Western Metal Exposition and Congress. This is *your* opportunity to sell and to serve this great western market.

SHOW — how to use your product most efficiently.

TELL — about new and improved products that will achieve greater industrial output.

WESTERN METAL EXPOSITION

March 19-23, 1951
Oakland,
California

Reserve your display space now and join in this important western event.

Write or wire collect today for floor plans and complete information — W. H. Eisenman, Managing Director, Western Metal Exposition, 7301 Euclid Avenue, Cleveland 3, Ohio — phone UTAH 1-0200.

WESTERN METAL EXPOSITION

OAKLAND, CALIFORNIA

IS Heat Shock WARPING YOUR FURNACE FIXTURES?



The extreme flexibility of these PSC jointed trays prevents self-destruction from warping and cracking. Most frequently used in roller or rail type brazing furnaces, these PSC units are recommended for use wherever higher-than-usual temperatures cause tray trouble. They are now standard with over a score of the largest automotive and metal-working firms.

PSC flexible trays are made in any length or width by assembling sheet alloy channels with tube spacers. In addition to flexibility, their light weight is another important source of operating savings. By eliminating many pounds of production-losing weight, PSC sheet alloy trays cut fuel costs and brazing cycles.

The unit pictured above, fabricated of Inconel, is 24 x 36 in., weighs about 50 lbs., and handles loads up to 80-90 lbs. However, we have made these

trays in a dozen different sizes, and in as many different modifications of design to suit specific applications in brazing and other heat-treating operations.

As pioneer of light-weight sheet alloy heat-treating equipment, we offer you a wealth of experienced engineering assistance. The services of our technical staff are freely available.

Light Weight Heat-Treating Equipment for Every Purpose

Carburizing and Annealing Boxes	Tumbling Barrels - Tanks
Baskets - Trays - Fixtures	Cyanide and Lead Pots
Muffles - Retorts - Racks	Thermocouple Protection Tubes
Annealing Covers and Tubes	Radiant Furnace Tubes and Parts
Pickling Equipment	Heat, Corrosion Resistant Tubing

PSC standard or special heat-treating equipment is furnished in any size or design. We fabricate the complete list of alloys, permitting you to choose the metal that is "alloy right" for your heat and corrosion requirements. Send blue prints or write as to your needs.



THE PRESSED STEEL COMPANY of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING Sheet Alloys

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆



The Microcarb Control for the new Series H Homocarb Furnace occupies panel at left in above photo, next to the usual temperature control panel. (1) is the Carbohm primary element; (2) the Microcarb controller for carburizing atmosphere; (3) the Micromax Atmosphere Recorder.

Now!

Users of the Series H Homocarb furnace equipment can regulate steel surface carbon content as easily, automatically, as temperature is controlled. Now, for the first time, carbon content of furnace atmosphere can be continuously regulated for the desired type of controlled surface carburizing, homogeneous carburizing, carbon restoration and annealing.

This new feature is called Microcarb Control. It consists of three units: (1) a carbon detecting primary element...called a Carbohm...located right in the furnace work chamber; (2) Microcarb Controller which regulates throughout a range of 0.15 to 1.15% of carbon; (3) Model S Micromax Recorder, which gives a continuous and permanent

Carbon content of steel surfaces AUTOMATICALLY CONTROLLED in Homocarb Furnaces

record of per cent of carbon in furnace atmosphere.

Microcarb Control automatically regulates the flow of Homocarb fluid so as to control the carbon potential of the furnace atmosphere. This means the surface chemistry of the steel being treated can be either maintained or changed to give any desired carbon content. Microcarb Control added to the Series H Homocarb furnace, with its many important features . . . its solid bottom retort, new fan housing and work support, aerodynamically designed vanes and discharge jets . . . makes the furnace equipment a superior tool for improving quality and cutting costs of heat treatment.

For further information, write us at our nearest office or at 4927 Stenton Avenue, Philadelphia 44, Pennsylvania.



MEASURING INSTRUMENTS • TELEMETERS • AUTOMATIC CONTROLS • HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jnl. Ad T-620(30)

November, 1950; Page 643



a full day's production...every day!

Champion DeArment Tool Company, Meadville, Pa., use the

Lindberg 2-station Induction Heating Unit to harden their famous CHANNELLOCK pliers. Their unit, like all other Lindberg Induction Heating Units, is designed to give a full day's production every day... without costly, irritating breakdowns that skyrocket production costs ★★ **Oversized Components**—oversized components, built into every Lindberg Unit, insures uninterrupted production and hundreds of "bonus hours" of service life ★★

Safety Overloads—safety overloads, designed for any eventuality protect valuable equipment, reduce rejects and guard against human error ★★ **"Checklite" Trouble Shooting**—a built-in "CHECKLITE" system maintains a constant vigil, and when safety overloads operate a signal light indicates the location of the overloads for immediate correction ★★ For full details on 5, 10, or 25KW Units, write for Bulletin

1419. Lindberg Engineering Company,
2448 West Hubbard Street, Chicago 12, Illinois.



LINDBERG
HIGH FREQUENCY DIVISION

9 stamina in dies



Made from steel developed by Finkl, these quenched and tempered die blocks are ready to hammer away at production records. The blocks are water quenched which develops deep hardness penetration characteristics with uniformity of hardness at each level. Such treatment also promotes good machinability, toughness, ductility, and the blocks are highly resistant to checking and washing and free from temper brittleness.

Should your die needs require high resistance to abrasion, high hardness ratings, or if you are confronted with any difficulties in forming ferrous or non-ferrous metals, Finkl has a die block for your application, and a service engineer to help with your problems.

For over 70 years Finkl has produced quality products. This experience and knowledge is available to you in planning your forging production. Call or write any of the offices listed below.



A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

DIE BLOCKS AND INSERTS • PISTON RODS & RAMS • SOW BLOCKS • CRANKSHAFTS

Eastern Warehouse

INDUSTRIAL STEEL, INC.

250 Bent Street, Cambridge 41, Mass.

Western Warehouse

FINKL STEEL PRODS. OF CALIF.

4908 Santa Monica Blvd., Los Angeles 27, Calif.

Boston, Michigan & Cleveland, Ohio • Birmingham, Pennsylvania • Louisville, Ky. • St. Louis, Mo. • Milwaukee, Texas • Indianapolis • Atlanta • San Francisco, Calif.

GAS CARBURIZING TRAYS

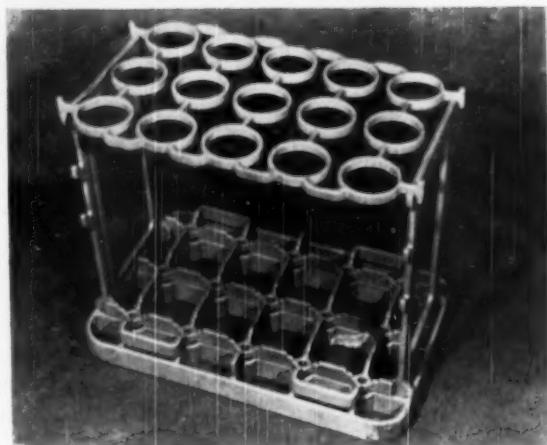
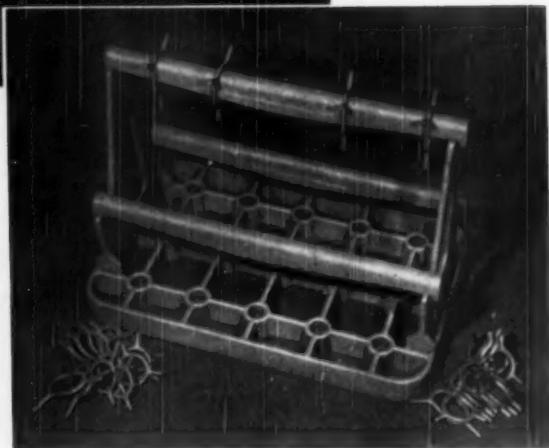
*Job-proven
in Industry!*

The design of gas carburizing trays and fixtures to obtain maximum service life requires a thorough knowledge and understanding of

- the effect of temperature differentials of each application.
- effect of black body conditions of each specific loading.
- effect of square corners and small radii.
- effect of unequal sections.
- effect of cooling rates in the mold, the furnace, and the quench tank.
- plus a complete knowledge of foundry techniques to obtain the highest quality castings.

Hundreds of trays are being used by industries with unnecessary designed-in self-fatiguing stresses which are costing the consumer thousands of dollars per year through decreased service life.

If you are interested in lower heat-hour costs, call an ACCOLOY ENGINEER for an honest analysis of your problem. There is no obligation on your part.



WE MAKE: MUFFLES · RETORTS · BELTS · CHAIN
ROLLER RAILS · CARBURIZING BOXES · SALT POTS

ALLOY ENGINEERING & CASTING COMPANY

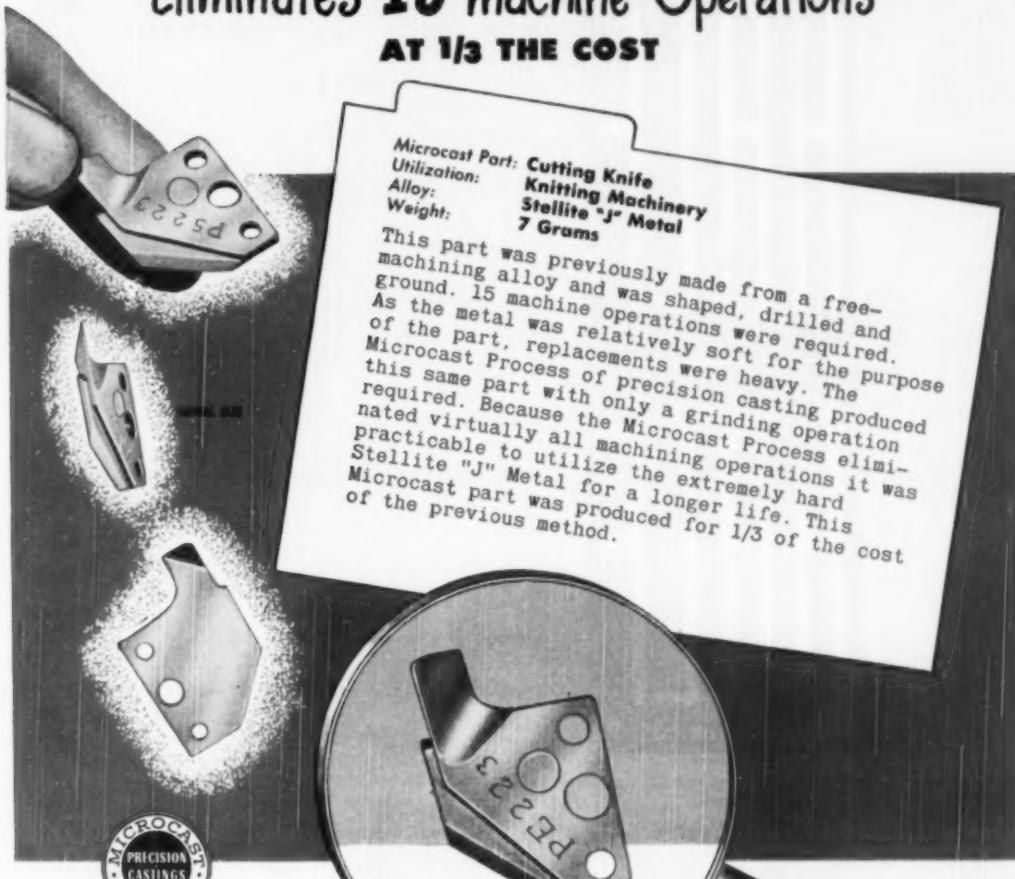


ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

ALLOY CASTING CO. (DIVISION)
CHAMPAIGN, ILLINOIS

MICROCASTING

Eliminates 15 machine Operations AT 1/3 THE COST



MICROCAST T.M. REG. U.S. PAT. OFF.

Microcast components of intricate shape may be produced of the extremely hard, high melting point alloys because as cast they are dimensionally uniform, of sound structure and to such close tolerances that little or no machining is required.

WRITE FOR FREE BOOKLET—More complete information on the Microcast Process is contained in a 16-page booklet which describes many applications for Microcast, specifications and a step-by-step explanation of the process itself. Write for this valuable booklet today!

November, 1950; Page 647

**Microcast Part: Cutting Knife
Utilization: Knitting Machinery
Alloy: Stellite "J" Metal
Weight: 7 Grams**

This part was previously made from a free-machining alloy and was shaped, drilled and ground. 15 machine operations were required. As the metal was relatively soft for the purpose of the part, replacements were heavy. The Microcast Process of precision casting produced this same part with only a grinding operation required. Because the Microcast Process eliminated virtually all machining operations it was practicable to utilize the extremely hard Stellite "J" Metal for a longer life. This Microcast part was produced for 1/3 of the cost of the previous method.



MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

HALF

Fluid-film

the other

HALF

metal cleaner SC-9

Half of this message has to do with the drawing of steel, stainless steel, aluminum, brass with FLUID-PIEL U-19 . . . It is non-corrosive to dies and metals . . . applied with brush, roll, dip, spray,—weld through it. FLUID-PIEL, a non-pigmented, semi-emulsion compound performs the toughest job economically—a little of it goes a long way . . .

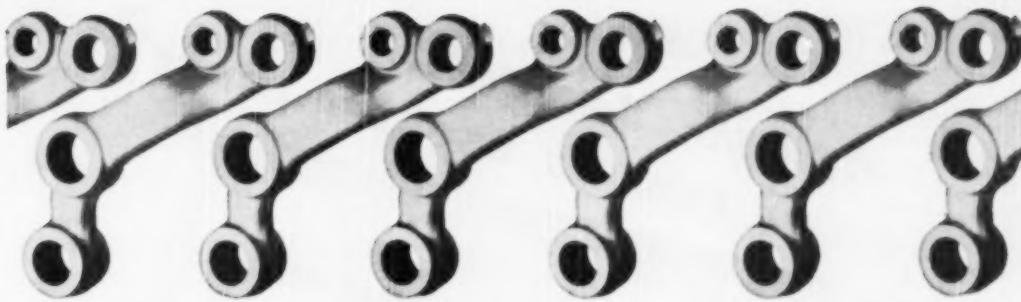
is concerned with the cleaning of stampings drawn with FLUID-PIEL in pressure washing equipment with Northwest Metal Cleaner SC-9. It has been on the market for years and is thoroughly plant proven for all washing machine use regardless of application. SC-9 is still one of the lowest priced cleaners in spite of the alkali price increase . . .

NORTHWEST CHEMICAL CO.
9310 ROSELAWN

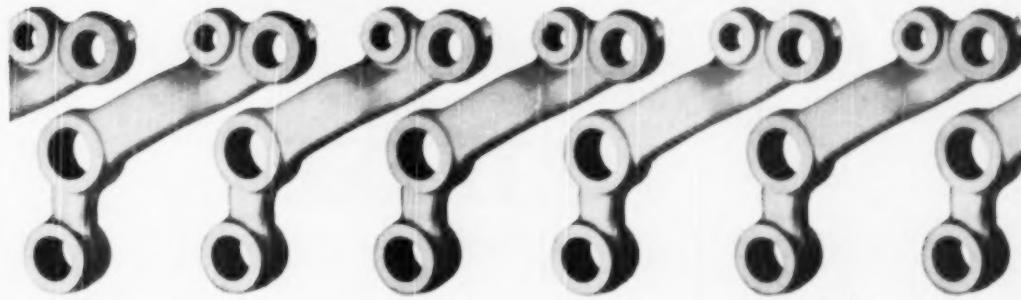


DETROIT 4, MICH.

SERVING YOU SINCE '32



You get uniformity every time



with **TIMKEN®** forging steels!

THE uniform forgeability of Timken® forging steels, plus their superior surface and internal quality, gives you better finished forgings at lower cost.

From bar to bar, heat to heat, Timken forging steels have uniform chemical and physical properties, uniform response to heat treatment, uniform machinability. As a result, your rejects are reduced. You have fewer delays and shop-practice changes to boost costs. And the performance of your forgings is consistently good.

That's *assured*—because Timken steels are tailor-made to your specifications, under the most modern, precise quality control methods known. What's more, every fifth man in the mill spends full time on inspection.

For help with your problems, get an on-the-job analysis by our Technical Staff. No obligation. Also write on your letterhead for our authoritative, 112-page book, "Evaluating the Forgeability of Steels". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphite and standard tool analyses—and alloy and stainless seamless steel tubing

Now you can get...
BETTER FINISHES, BROADER USAGE
for ZINC AND CADMIUM
with
IRIDITE
for



**CORROSION RESISTANCE, PAINT ADHERENCE,
 FINAL FINISH... BRIGHT, CHROME-LIKE OR COLORED**

The only complete line of patented chromate-dip treatments to meet your particular finishing problem.

Iridite quality is tops in corrosion resistance and paint bond. Iridite finishes are first in wide selection of coatings:

BRIGHT: Chrome-like in appearance

BRONZE: Natural as bronze itself

OLIVE GREEN: A popular replica of Military Olive Drab.

HUE BRITE: Clear; eye-appealing iridescence

COLORS: Black, Red, Blue, Green

PROCESS METHOD: Simple dip chemical immersion for a matter of seconds

SURFACES: Zinc or cadmium: plated, die cast, galvanized or sheet

COST: The smaller fraction of a penny does a square foot of surface

FREE—Write for literature and samples, and for immediate action, send us a sample of the product you wish to process, along with the outline of your problem.

SPECIAL PROCESSES—Research and new developments in general metal finishing are being carried forward as manufacturers present new finishing problems for us to work out. **Let us go to work on yours.**

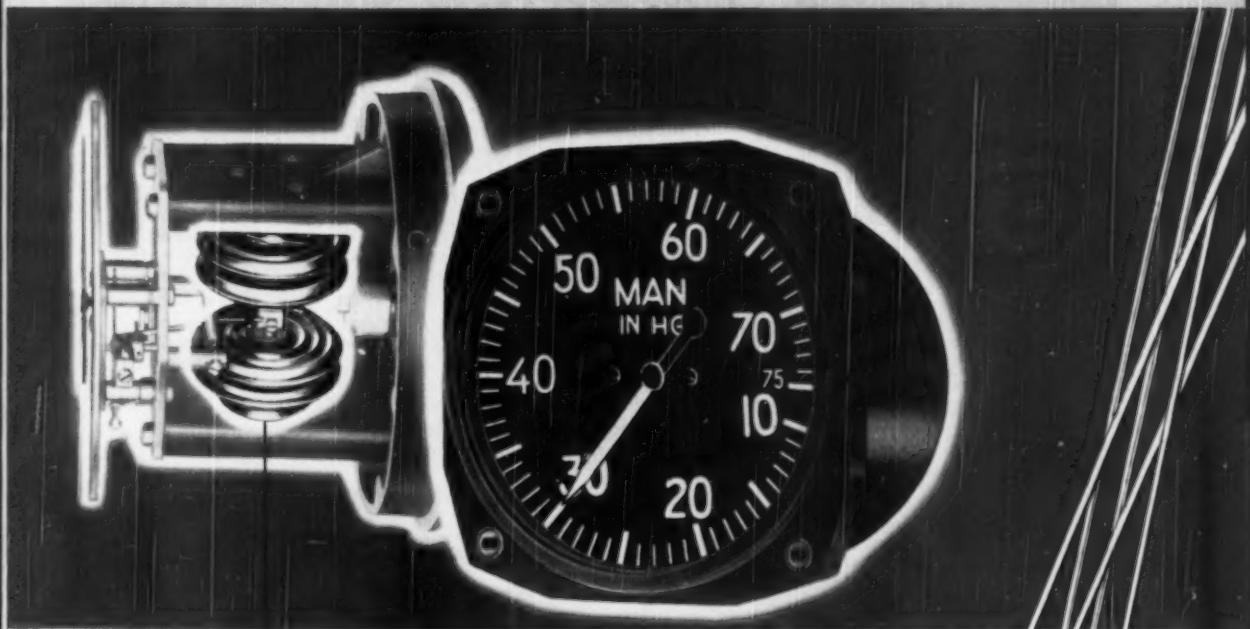
IRIDITE LICKED THESE FINISHING PROBLEMS—Washing Machine Parts • Radio Equipment • Kitchen Utensils • Aircraft Parts • Lock Hardware • Office Machines • Window Frames • Vending Machines • Tools • Lamp Fixtures • Fuel Pumps • Carburetors • Auto Hardware • Zinc Coated Sheet • Hinges, Screws, Bolts • Camera Parts • Plumbing Fixtures • Wall Panels • Refrigerator Parts • Wire Products • Instrument Parts • Electrical Equipment • Armed Forces Materiel.

**ALLIED RESEARCH
 PRODUCTS, INC.**

4004 EAST MONUMENT STREET
 BALTIMORE 5, MD.

West Coast Licensee—L. H. Butcher Company, Los Angeles 23, Cal. • Other Licensees in South Africa, South America, Australia

**THIS TIRELESS METAL THAT KEEPS GAUGES HONEST
MAY REVOLUTIONIZE YOUR PRODUCTS**



United States Gauge, world's largest manufacturer of gauges, uses Riverside Beryllium Copper for both pressure and vacuum diaphragm capsules of its absolute pressure instruments.

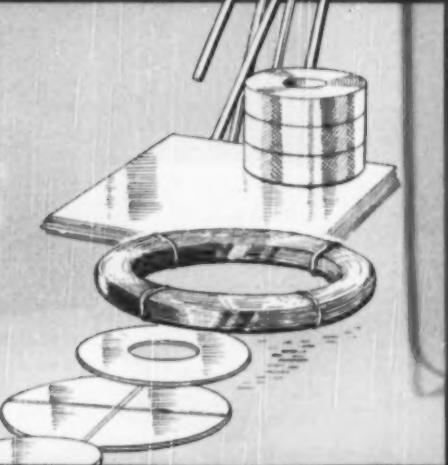
There's no place for muscle-bound metals in the diaphragms of an absolute pressure gauge. Constantly *sensing and reporting* changes in manifold pressure of internal combustion engines, diaphragms must be super-sensitive yet rugged enough to withstand flexure.

Beryllium copper, one of the alloys made by Riverside, is the only metal possessing the necessary physical properties that will do the job economically. In this application beryllium copper is "cold worked" to a tensile of 80,000 pounds, and formed *while being heat treated* to a tensile of about 210,000 pounds. Beryllium copper diaphragms easily take the initial stresses caused by evacuating air and the ever changing stresses of flexure.

Because of these advantages—plus corrosion resistance, wear resistance, formability and superior electrical and thermal qualities—Riverside Beryllium Copper finds wide use in gauges, springs, thermostats, bearings, gears, valve sleeves and seats. This versatile alloy—or one of the other Riverside metals, *Phosphor Bronze*, *Nickel Silver* or *Cupro Nickel*—may be the specific answer to your alloy problem. We produce these alloys in standard or special grades to meet your requirements. And we'll be glad to work with your technicians in examining and solving your particular puzzle.



If alloys are giving you trouble—in processing or in service—send the case history to Riverside. Also, be sure to ask for our new pocket-size Alloy Handbook. It's invaluable as a handy reference and a guide to alloy specification—and it's yours without obligation.



**RIVERSIDE
ALLOYS**

Alloys developed by research, proved by use

phosphor
bronze
•
nickel silver
•
cupro nickel
•
beryllium
copper

THE RIVERSIDE METAL COMPANY

Riverside, New Jersey

Newark, N. J. • Cleveland, Ohio • Chicago, Ill.
Hartford, Conn. • Rochester, N.Y. • Detroit, Mich.

Export Agent, International Brass & Copper Co., Inc., 62 Broadway, New York City

Controlled QUENCHING PRESERVES THE QUALITY!

The degree of control exercised in quenching heat-treated metal determines the amount of time and materials wasted by sub-standard rejects . . . and ultimate operating costs!

You can be sure of better results if you rely on a B & G *Hydro-Flo* Oil Quencher. The temperature desired in the quench bath will be accurately maintained throughout the quench period. The oil will be strongly agitated to avoid formation of gas bubbles which cause irregular surface hardness. Your product will emerge *uniform in quality*—every time!

While B & G *Hydro-Flo* Oil Cooling equipment can be purchased in separate units for assembly on the job, many heat-treaters are buying B & G Self-Contained Coolers. The advantages are obvious—all parts are factory-assembled into one complete unit, ready for immediate installation.

Bring your quenching problems to the B & G engineering department—there's no obligation in discussing them.

B & G Series "OC" *Hydro-Flo* Oil Cooler

Completely self-contained—equipped with
Cooler, Pump, Motor, Strainer and Controls.
Capacities to 2000 lbs. of steel per hour.



Send for this combined
Catalog and Simplified
Selection Manual.



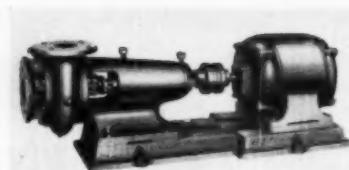
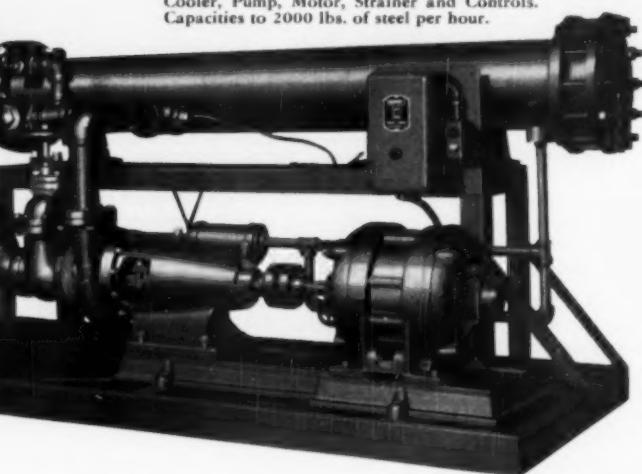
Hydro-Flo OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. BU-16, Morton Grove, Illinois

Heat-treating equipment
since 1916

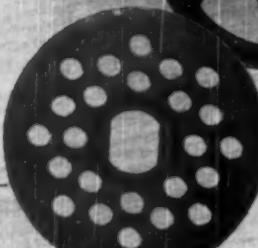
Reg. U. S. Pat. Off.



A complete line of flexible and close-coupled
centrifugal pumps. Send for engineering data.

STAINLESS STEEL KNIVES HELP MAKE

Grind-O-Mat
"Grindingest" Grinder in the World



EDGE-HOLDING KNIVES of Sharon STAINLESS steel assure Grind-O-Mat owners fine cutting performance forever. Juices of the strongest variety will not harm the blades. The dense STAINLESS surface cleans easily, stays sanitary. STAINLESS steel has enabled Rival to build a better-performing, longer-lasting, better-selling product.

The beautiful new Rival Grind-O-Mat has everything — base that firmly grips any smooth surface without clamps — large, round food hopper that fits the hand and slopes for food drainage, detachable for quick rinsing — smooth attractive exterior, easy to keep sparkling clean — and cutting knives of edge-holding, non-rusting STAINLESS STEEL. No wonder folks who have used the new Grind-O-Mat say — "It's the 'grindingest' grinder ever!"

Sharon STAINLESS makes any product a better product. Think about STAINLESS for your particular use — and when you do — think of Sharon — pioneer and prime producer of fine steels for fifty years. Fabrication information, engineering data upon request.

SHARON STEEL CORPORATION

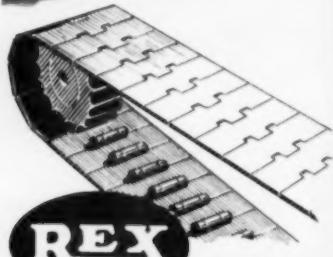
Sharon, Pennsylvania

PRODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL DIVISION, DETROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNA.; CARPENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, W. VA.; JOANNE COAL COMPANY, RACHEL, W. VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoop—Electrical Steel Sheets—Hot Rolled Annealed and Deoxidized Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

DISTRICT SALES OFFICES: Chicago, Ill., Cincinnati, O., Cleveland, O., Dayton, O., Detroit, Mich., Indianapolis, Ind., Milwaukee, Wis., New York, N. Y., Philadelphia, Penna., Rochester, N. Y., Los Angeles, Calif., San Francisco, Calif., St. Louis, Mo., Montreal, Que., Toronto, Ont.



Two type HD 2436 Hevi Duty Vertical Retort Furnaces in use at The Chain Belt Co., Milwaukee, Wis.



REX

**TABLE TOP
CHAIN**

is heat-treated in modern
HEVI DUTY FURNACES

For dependable results that
add extra quality to Rex
Table Top Chain, each section
is case hardened in
a Hevi Duty Furnace.

It's the Reliability of HEVI DUTY FURNACES

*that enables you to CUT the COSTS of
case hardening parts for your product*

These versatile Hevi Duty Electric Furnaces at the Chain Belt Co., of Milwaukee are in daily use carburizing, hardening, and annealing the many diversified parts used in REX Chains.

Typical of the many heat treated parts are the sections of the popular REX TABLE TOP conveyor chain. Where minimum distortion during heat treatment is a necessity and accurate case depths must be maintained, Hevi Duty Furnaces are first choice.

Send for Bulletin HD 646

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES

HEVI DUTY

ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

Warehouses
District Offices

Nationally known

- ★ **Red Cut Superior**
America's best known tungsten high speed steel—for all cutting purposes.
- ★ **Red Cut Cobalt**
Extra Duty—heavy cuts, fast speeds, hard or abrasive materials.
- ★ **E. V. M.**
Tungsten steel with higher vanadium—for increased tool life.
- ★ **VAN-LOM**
Molybdenum—Vanadium steel for all cutting tool purposes—especially good for fine edge tools.
- ★ **8-N-2**
Low tungsten—Molybdenum steel for all cutting tool purposes.
- ★ **Vasco M-2**
Tungsten-Molybdenum general purpose steel.
- ★ **Neatro**
Superior Wear Resistance—delivers top performance on non-ferrous materials, cast steel, cast iron, heat treated steels.
- ★ **Vasco Supreme**
Entirely New—higher hardness, higher wear resistance, higher hot hardness, higher speeds.



High Speed Steels

Our Latrobe, Pennsylvania plant is the only steel mill in the world devoted *exclusively* to the manufacture of high speed steel.* No wonder you are assured of steels free from harmful segregation—free from harmful decarburization—free from contamination. No wonder Vanadium-Alloys steels are the *first choice of most manufacturers* of drills, reamers, taps, broaches, milling cutters, form tools, hobs, chasers, counterbores...wherever maximum performance is a necessity!

*Carbon and alloy tool steels are produced by our Colonial Steel Division.

Vanadium-Alloys

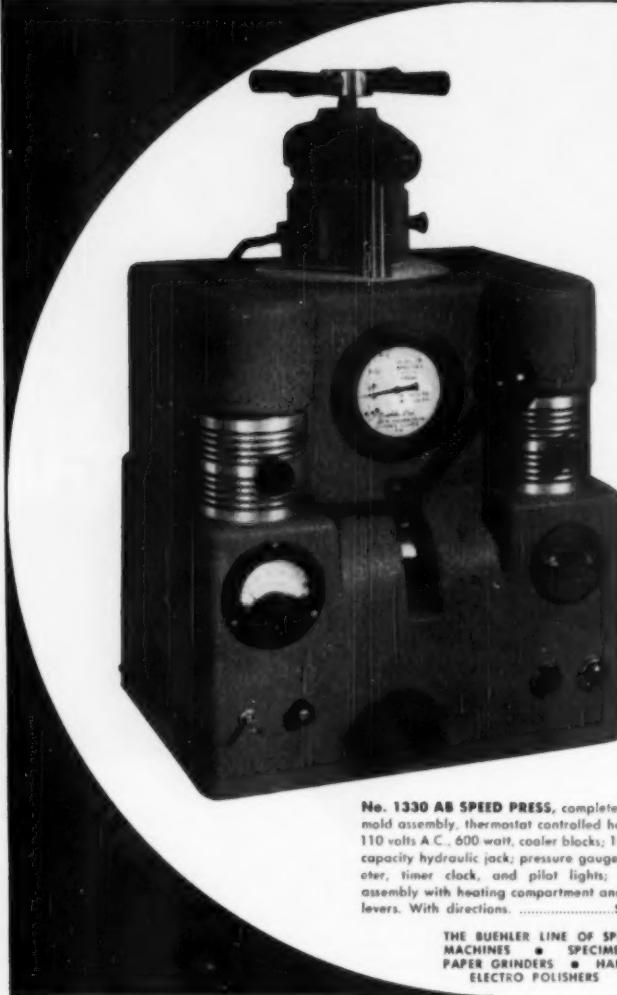
STEEL COMPANY
LATROBE, PENNA.

Colonial Steel Division

Anchor Drawn Steel Co.



Announcing THE NEW AB SPEED PRESS



This Streamlined AB SPEED PRESS

offers the metallurgist a new tool with the unparalleled qualities of precision workmanship, speed and convenience in the preparation of metallurgical specimens into plastic mounts.

The new AB SPEED PRESS produces perfect Bakelite mounts in 2½ to 3½ minutes and may be used with 1", 1¼" or 1½" molds.

Our introduction of preheated Premolds has revolutionized the preparation of metallurgical specimens.

The Premolds are dust-free, increase the convenience in handling, and are available at little extra cost. The Preheat Compartment reduces the curing time of thermoset molds to one-third of the time. The operation is controlled by Pyrometer, Timer and Thermostats.

These features in the new AB SPEED PRESS are destined to set a new mark in the development of metallurgical specimen preparation. It provides all metallurgists with the most advanced press equipment for speed, convenience, and economy never known before.

No. 1330 AB SPEED PRESS, complete with 1" mold assembly, thermostat controlled heater for 110 volts A.C., 600 watt, cooler blocks; 10,000-lb. capacity hydraulic jack; pressure gauge, pyrometer, timer clock, and pilot lights; premold assembly with heating compartment and ejector levers. With directions. **\$380.00**

No. 1330-2 AB SPEED PRESS complete, same as No. 1330, except for 1½" mountings. With directions. **\$400.00**

No. 1330-3 AB SPEED PRESS complete, same as No. 1330, except for 1¼" mountings. With directions. **\$430.00**

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS

165 West Wacker Drive, Chicago 1, Illinois



Bulletin on SUPER REFRACTORIES



by **CARBORUNDUM**

TRADE MARK

NO. 12

NOVEMBER, 1950

How Can You be Sure of Proper Selection of Super Refractories?

The table below shows that the line of super refractories offered by The Carborundum Company includes several distinct product groups. Each has specialized characteristics — equally important in both high- and low-temperature applications. Beyond these basic groups, however, are many modified varieties, each developed to better withstand a particular combination of conditions. Consequently, the selection of the best possible material for a given installation becomes involved.

It is for this reason that you should have no hesitation in asking for the assistance of CARBORUNDUM field engineers. These men have had wide ex-

perience with super refractories and their application to many different types of furnaces and kilns.

Supporting the work of these field engineers is CARBORUNDUM's technical group. Not only is this group close to both manufacturing operations and research programs — they are also in touch with developments throughout the world involving new processes using super refractories. These men have the broad product and application knowledge that is most helpful in considering unusual new installations.

You can be sure of getting the right super refractory for your job when you bring your problem to CARBORUNDUM.

Physical Properties of Super Refractories by CARBORUNDUM

Trade Mark

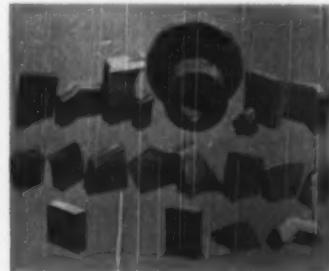
	CARBOFRAX Silicon Carbide	MULLFRAX Electric Furnace Mullite	MULLFRAX S Covered Kyanite	ALFRAX K Alumina	ALFRAX B Electrically Fired Alumina	ALFRAX BI Electrically Fired Alumina
Heat Conductivity at 2300° F. in BTU/ hr. sq. ft. and °F. (in. of thickness)	109 BTU	16 BTU	9 BTU	24 BTU	12 BTU	7 BTU
REFRACTORINESS PCE CONE	37-40	38-39	37-38	37-39	39-40	38-39
SPALLING RESISTANCE	High	High	High	Good	Good	Good
ABRASION RESISTANCE	High	Medium	Medium	High	Medium	Low
THERMAL EXPANSION (23° — 1400° C.)	.0000044	.0000059	.0000069	.0000074	.0000086	.0000086
MODULUS OF CUTURE @ 2400° F. PII	800-3125	100-250	175-475	100-1050	100-225	50-100
WEIGHT 9 IN. STRAIGHT	9.25 lbs.	9 lbs.	8 lbs.	10.1 lbs.	7.25 lbs.	4.8 lbs.



Proper Use of CARBOFRAX Checkers Can Increase Gas-Make

With CARBOFRAX silicon carbide checker brick properly applied in carburetors, superheaters, and oil-gas generators by CARBORUNDUM field engineers, operators can increase their gas-make and lower their operating costs. CARBOFRAX checkers, because of their high thermal conductivity and high emissivity, absorb more heat in less time. For the same reasons the heat is released to the gas stream more rapidly during regeneration.

With their unusual refractoriness, great density and low iron content, CARBOFRAX brick last longer and provide cleaner checker settings. In other words — with CARBOFRAX brick you get better oil efficiency, increased cracking capacity, lower checker maintenance, and savings in the solid fuel.



Jig-saw — of CARBOFRAX Shapes!

These are some of the pieces that made up a refractory lining designed by CARBORUNDUM engineers for a metallurgical process. In all, there were several thousand pieces — and about 1000 of them were of different keyed, fitted shapes.

The problem was to furnish a lining that molten metal would not penetrate, that could withstand rapidly fluctuating

"Carborundum," "Carbofrax," "Mullfrax," "Silfrax," "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company
Address all correspondence to: Dept. C-110, THE CARBORUNDUM COMPANY, Refractories Division, Perth Amboy, New Jersey

Continued on other side →

→ Continued from other side

pressures, and that would perform under unusually high temperatures. CARBOFRAX silicon carbide tile was the answer — in special and intricate shapes which would fit the complicated shell. With elbows and bends, every piece had to be keyed to fit, with accurate tight joints — and the completed lining mechanically stable.

The result? An amazing performance record, far surpassing any previous lining — more proof of what the correct grade of CARBOFRAX materials will do when engineered to the job.



Kiln Furniture Designed by CARBORUNDUM Engineers Improves Performance

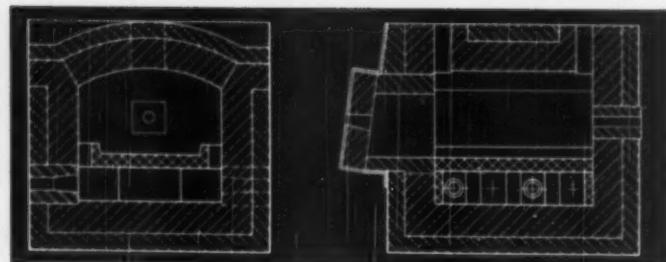
These are the advantages a sanitary-ware producer reports from using CARBOFRAX silicon carbide tile and CARBOFRAX streamlined posts in this car structure laid out by CARBORUNDUM engineers:

Greater loading capacity — With thin CARBOFRAX slabs and streamlined posts, there is more space for setting ware. Placing, too, is easier.

Fewer rejects — The clean CARBOFRAX kiln furniture prevents ware marking. Even after long service, there is no dripping and blistering.

Less frequent rebuilds — With CARBOFRAX furniture, cracking and warping are practically eliminated. Post deformation is no problem. Replacement and maintenance expenses are reduced to a minimum.

The properties of CARBOFRAX tile and posts make them unique for such applications. With their high hot strength, they can support heavy loads without sagging. With their exceptional resistance to heat shock, they will not crack prematurely. Their high thermal conductivity means quick, uniform heat transfer. All in all, they will increase production and lower costs.



Small Oven Furnaces — Perform Better When Super Refractories Are Properly Used

Increased production and operating economies almost always follow the installation of a CARBOFRAX hearth in a small oven furnace. The high thermal conductivity of this super refractory means rapid heat transfer, with quicker temperature come-back after charging, and more uniform heat distribution throughout the chamber. With cold spots eliminated, there are fewer rejects. Maintenance expense, too, is cut — with its high resistance to mechanical abrasion, and to cracking, a CARBOFRAX hearth lasts longer.

However, super refractories have even more possibilities in such furnaces. CARBOFRAX silicon carbide or MULLFRAX electric-furnace mullite supports last longer and improve quality of work by keeping the floor flat and level. Burner ports and door blocks of MULLFRAX's converted kyanite blocks promote more continuous operation, reduce maintenance. Even main linings will last longer — and improve furnace efficiency — when partially or entirely constructed of ALFRAX BI aluminum oxide brick or shapes.

For Melting Furnaces, Too Let CARBORUNDUM Engineers Select Your Lining

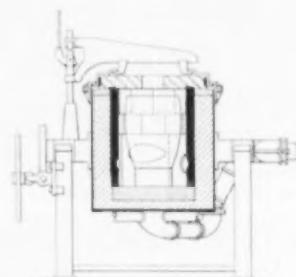
Non-ferrous metal melting furnaces, such as shown in the drawing at right, almost invariably give better results when properly lined with CARBOFRAX silicon carbide shapes:

Lining costs come down — With their high resistance to spalling, cracking and flame erosion, CARBOFRAX linings last longer. Lining costs are lower per pound of metal melted.

Production goes up — CARBOFRAX linings need be only 1 1/4-inches thick. Consequently heavier insulation can be used — and the heat capacity of the furnace structure will be lower. Melting rates are faster; you can get more heats per shift.

Maintenance costs are reduced — Not only do CARBOFRAX linings last longer, but when replacement is finally necessary, it can be made easily and quickly. The individual CARBOFRAX tile are accurate in size, and have rugged interlocking joints. Frequent patching can be avoided, too — saving further on labor costs.

CARBOFRAX linings are stocked in a wide variety of sizes. Special sizes can be produced quickly to order.



To obtain facts and figures on installations in specific fields merely select from this list of bulletins. Copies will be sent you at once. No obligation, of course.

Super Refractories by CARBORUNDUM (general catalog)

Super Refractories for the Ceramic Industry

Super Refractories for the Process Industry

Super Refractories for Boiler Furnaces

Super Refractories for Heat Treatment Furnaces

Super Refractories for Gas Generators

The Frax Line of Cements

CARBOFRAX Refractory Skid Rails

Porous Media for Filtration & Diffusion

Dept. No. C-110

THE CARBORUNDUM COMPANY

Refractories Division

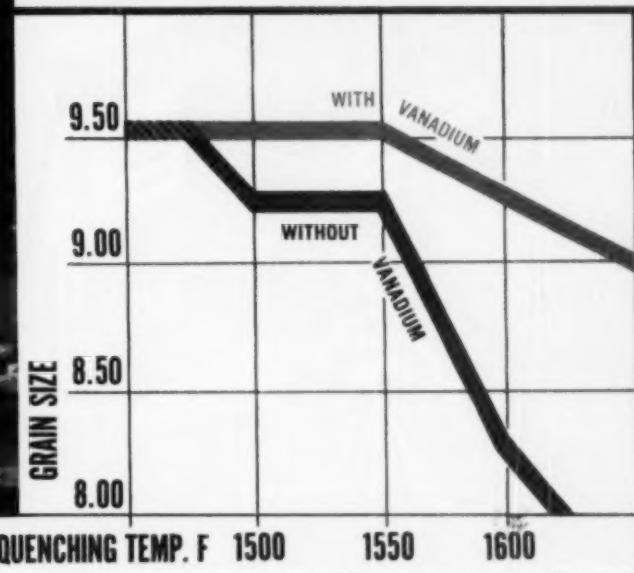
PERTH AMBOY, NEW JERSEY

VANADIUM
does big things for

BTR
TOOL STEEL



FINER GRAIN WITH VANADIUM! Here is graphic evidence of the grain refinement due solely to the vanadium addition. The finer grain improves shock-resistance, makes response to heat-treatment more foolproof.



BTR has the edge on oil-hardening, general-purpose tool steels which contain no vanadium. We've got conclusive proof that adding a little vanadium makes a whale of a difference!

Our laboratories have just concluded exhaustive tests in which BTR was put through its paces along with many other top grades of oil-hardening tool steel. Tests were conducted on all steels to compare such properties as: machinability, ease of hardenability, resistance to wear and shock, both maximum and annealed hardness and distortion in heat-treatment.

Accurate test data show that BTR retains a finer grain in hardening. BTR is less critical, more foolproof in heat-treating; it's less likely to develop cracks in quenching. It has greater shock-resistance, too. All of these characteristics are improved by the vanadium addition. That's why we have included this important alloying element in BTR's analysis for so many years.

Veteran toolmakers rely on BTR because it is safe-hardening . . . easy to machine and heat-treat . . . and because it has good resistance to wear and shock . . . assures low distortion in heat-treatment. It's useful in every toolroom for a wide variety of tools and dies. BTR is stocked by Bethlehem Tool Steel distributors everywhere. If you prefer, write us at Bethlehem, Pa.

Typical Analysis: C Mn W Cr V
 0.90 1.20 0.50 0.50 0.20
 (harden at 1475 F . . . quench in oil)

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation, Export Distributor; Bethlehem Steel Export Corporation



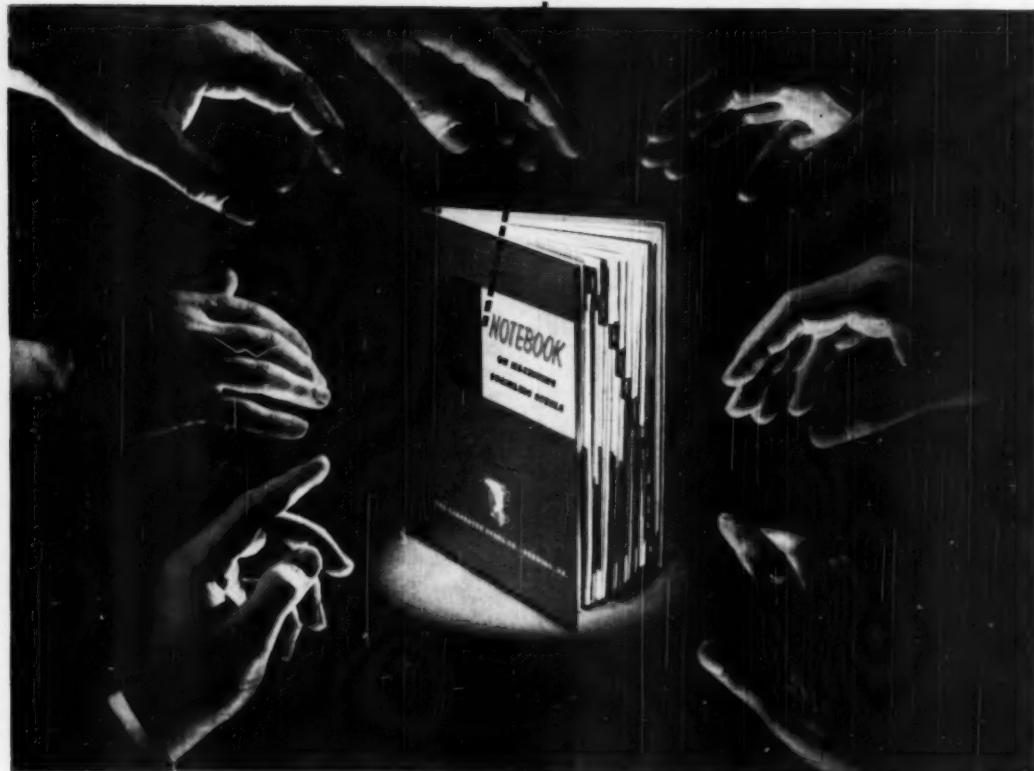
Bethlehem



Tool Steel



MARKS THE SPOT



...Where Carpenter Customers Find New Ways to Get Stainless Jobs Done Faster

It's easy to see how *less tool grinding* means less machine down time. And it saves because you make fewer tools. Reducing the number of rejects on Stainless jobs—getting the best possible finishes—can make a big difference in your unit production rate, too.

Many a customer of ours has found this a good formula for easier machining of Stainless. First use the Stainless that is *uniform* every time you get it—*Carpenter Free-Machining Stainless*. Then take advantage of the shop help Carpenter can give you.

For example, the men who work out of your nearby Carpenter Mill-Branch Warehouse will be glad to help out on any problems that come up. Or, we can give you a personal copy of the Carpenter "NOTEBOOK on Machin-

ing Stainless Steels". It's packed full of useful shop hints on turning, drilling, threading, milling, lubrication, etc. If you would like a copy, just write us a note on your company letterhead, indicating your title.

The Carpenter Steel Company, 133 W. Bern St., Reading, Pa.
Export Department: Woolworth Bldg., New York 7, N.Y.—"CARSTEELCO"

Carpenter
STAINLESS STEEL
takes the problems out of production



For Easy-to-Use Stainless Call Carpenter. Warehouses in principal cities throughout the country.



Free...

AIRCO'S NEW HAND TORCH CATALOG

—COMPLETE, AUTHORITATIVE INFORMATION . . . EVERYTHING
YOU NEED KNOW ABOUT AIRCO TORCHES

Just fill in the coupon below and mail it to us today. Upon receipt, we will send you —ENTIRELY FREE—Airco's new 36-page guide showing the right torch for light, medium or heavy welding, cutting, heating, brazing, descaling and flame hardening.

Here is the booklet that gives you complete data on all Airco torches —nationally famous for their ease of operation, durability and dependability. Divided into easy-to-read sections, the booklet quickly helps you select the torch best suited to your particular production or maintenance problem.

The booklet is handy, useful, bringing you a wealth of information covering design, specifications, tip requirements for special operations, and operating characteristics of each torch in the Airco line.

To give you a brief idea of the material covered, here are a few of the sections the booklet contains:

- 14½ pages of detailed easy-to-read charts covering every welding, cutting and special purpose tip in Airco's complete line . . . *these charts are not available from any other source*, and they show you how to select the **RIGHT** torch, tip, mixer and extension for any job.
- All-purpose and moderately priced welding and cutting outfits for heavy-duty or light day-to-day welding and occasional cutting are shown in an illustrated 4-page section.
- Invaluable data on the right accessory—guide roller attachment, flash circle burner, hose connections, couplings, and so on—for the job at hand.

But see the booklet yourself—send for it now. Just fill in and mail the coupon for your free copy.

Air Reduction Sales Company

A Division of Air Reduction Company, Incorporated
60 East 42nd Street, New York 17, N. Y.

Please send me a copy of Airco's NEW Hand Torch Catalog No. 2.

Name _____

Firm _____

Address _____

City _____ Zone _____ State _____



AIR REDUCTION

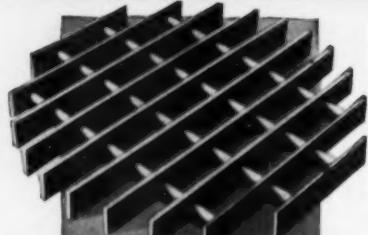
Air Reduction Sales Company • Air Reduction Magnolia Company • Air Reduction Pacific Company
Represented Internationally by Airco Company International
Divisions of Air Reduction Company, Incorporated

Offices in Principal Cities

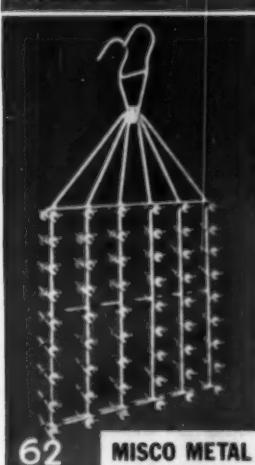
Headquarters for Oxygen, Acetylene and Other Gases... Calcium Carbide... Gas Cutting Machines
Gas Welding and Cutting Apparatus, and Supplies... Arc Welders, Electrodes and Accessories.

It's MISCO *for* HEAT RESISTING ALLOYS IN ROLLED MILL FORMS

Sheets — Plates — Rounds — Squares ■ Hexagons ● Flats — Angles L
Channels U Sections T Pipe O Nuts ○ Welding Rod Z



MISCO METAL (35-15)
Fabricated Grid for
Pit Furnaces



MISCO METAL (35-15)
Salt Bath Fixture

YOU NEED OUR MONTHLY
STOCK LIST

Send for it now and keep informed
on Rolled Misco Alloys in stock.

Rolled MISCO METAL (35Ni-15Cr-1½Si) is available in hundreds of sizes for handy, economical fabrication of heat treating fixtures and containers of all kinds. For your convenience in obtaining all your rolled alloy needs from one source, Misco maintains the largest and most complete stocks of rolled heat resisting alloys in the trade. For quality heat resisting alloys—send your orders to Misco.

Select the ALLOY that DOES YOUR JOB BEST

We also carry stocks of other Heat Resisting Alloys—They provide a correct alloy for most conditions of High Temperature service . . .

MISCO K—

MISCO B—

25 Cr-20 Ni Type 310 25 Cr-12 Ni Type 309

MISCO 430—

17 Cr Type 430

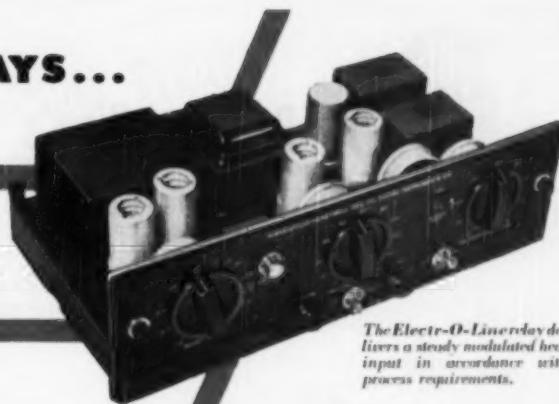
ROLLED PRODUCTS DIVISION
Michigan Steel Casting Company

MISCO
Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys
1998 GUOIN STREET • DETROIT 7, MICHIGAN

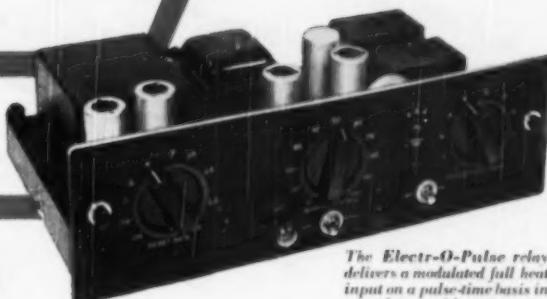
NEW CONTROL RELAYS...

Electr-O-Line



The Electr-O-Line relay delivers a steady modulated heat input in accordance with process requirements.

Electr-O-Pulse



The Electr-O-Pulse relay delivers a modulated full heat input on a pulse-time basis in accordance with process requirements.

FOR YOUR FURNACE FOR YOUR PRODUCT

FOR EXACTING CONTROL OF INDUSTRIAL FURNACES, Brown offers two new relays: the *Electr-O-Line* for position proportioning control and the *Electr-O-Pulse* for time proportioning control. Completely electronic and both providing automatic reset, these units are designed as an integral part of Brown Proportional Controllers or as separate models for modernizing existing installations. Outstanding features include:

- *Control adjustments are completely independent making "tuning in" process very simple.*
- *Manual control of the process may be accomplished from the relay.*
- *Plug-in type chassis simplifies servicing and wiring.*
- *Both the Electr-O-Line and Electr-O-Pulse relays are physically interchangeable with*

the Brown Manual Reset relay when used with Brown ElectronIK Proportional Controllers.

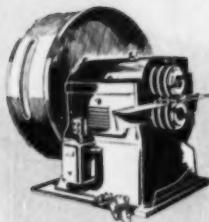
- *Designs are electronic and have no motor driven resistors.*

Brown Instruments, the most *complete* modern line of controllers, include the *right* control for your furnace . . . for your product. There need be no compromise on a control job . . . no need to "stretch" the application to fit the instrument. Your local Honeywell engineer can impartially advise you on the *correct type of instrument* for your requirements. Call him today . . . he is as near as your phone!

MINNEAPOLIS-HONEYWELL REGULATOR Co.,
Industrial Division, 4503 Wayne Ave., Philadelphia 44, Pa. Offices in more than 80
principal cities of the United States, Canada
and throughout the world.

MINNEAPOLIS
Honeywell

BROWN INSTRUMENTS



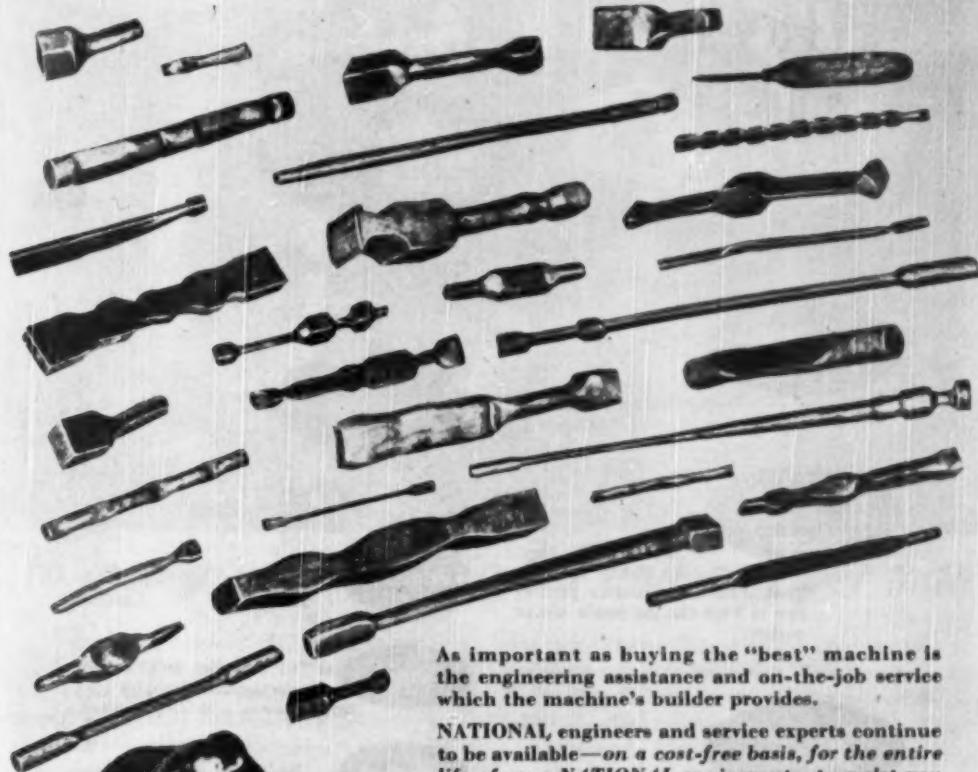
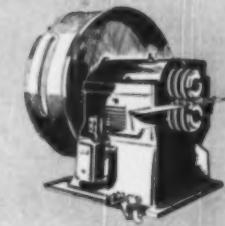
Reducerolling's really rolling along...

Typical REDUCEROLLED blanks shown on these pages indicate the extent to which this simple forging technique has been accepted by forgemen.

In a new approach to forge-shop cost-reduction, the rugged, versatile REDUCEROLL pre-forms blanks quickly for finish-forging on the same heat!



PREPARING FORGING BLANKS!



No. 4 REDUCEROLL

As important as buying the "best" machine is the engineering assistance and on-the-job service which the machine's builder provides.

NATIONAL engineers and service experts continue to be available—on a cost-free basis, for the entire life of your NATIONAL equipment—to assist you with any forging problem.

Whatever you need—die design, production procedures, maintenance, new development—NATIONAL'S long experience is "on call," yours for the asking!

Let us help you investigate the application of REDUCEROLLING to your work. Send us a print or sample of your forging—or, better yet, pay us a visit. No obligation, of course.

NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO.

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

Hartford

Detroit

Chicago

Ferro-alloys of quality

High Carbon Ferro-Chrome

4.7% Carbon, 65-70% Chrome, for chrome additions in making alloy steels.

Low Carbon Ferro-Chrome Silicon

Spec. .06% Max. Carbon, 38-42% Chrome, 38-42% Silicon. Used in production of high chrome steels low in carbon.

Manganese Sulphide

53-55% Manganese, 27-30% Sulphur, balance iron. Ladle addition for low cost production of free machining steels.

25% 50% 65% 75%

Ferro-Silicon

85% 90%

Covering every silicon requirement in the production of iron and steel.

Special Blocking 50% Ferro-Silicon

Specially designed and treated for blocking open hearth heats.

Ferro-Manganese

Standard High Carbon Grade . . . an assured source of supply.

Briquets

Silicon • Silico-Manganese Manganese • Chrome

Borosil

3-4% Boron, 38-42% Silicon; balance iron, for controlled boron additions to steel.

Simanal

An ideal deoxidizer for fine grained steels and steel castings.

SALES AGENTS AND WAREHOUSES:

SAN FRANCISCO AREA—Pacific Graphite Company, Inc., Oakland 8, California.

LOS ANGELES AREA—Snyder Foundry Supply Company, Los Angeles 11, California.

MINNEAPOLIS AREA—Foundry Supply Company, Minneapolis, Minnesota.

MEXICO—Casco S. de R. L., Apartado Postal 1030, Calle Atenas 32-13, Mexico D. F., Mexico.

SALES AGENTS:

NORTHWEST AREA—E. A. Wilcox Company, Arctic Building, Seattle 4, Washington; Phone Seneca 0193.

BIRMINGHAM DISTRICT—Schuler Equipment Company, First National Building, Birmingham, Alabama.





...to increase production per unit and per man"

"It must happen in a lot of shops. When a variety of metal working and metal cutting operations are involved, it's easy for the lubrication guides and the metal cutting requirements to get out of date. In our case, the outmoded requirements resulted in serious curtailment of per unit and per man production.

"We experimented quite a lot on our own but finally called in a Cities Service Lubrication Engineer. In an amazingly short time he diagnosed our trouble. Then he set up an air tight schedule. It

was easy to follow. It cost no more and the production results were immediate. This man knew his business. Our new production figures are definitely something to brag about."

Why not let a Cities Service Lubrication Engineer look over your operation. His service is free and the products he recommends are—absolutely—the best available on the market today. Get in touch with the Cities Service representative nearest you for lubrication advice and recommendations—or mail coupon below.



FREE . . .

**Fact-filled
New Booklet
For the Metal
Machining Industry**



CITIES SERVICE OIL COMPANY

Sixty Wall Tower, Room 747
New York 5, New York

Please send me without obligation your new booklet entitled "Metal Cutting Fluids."

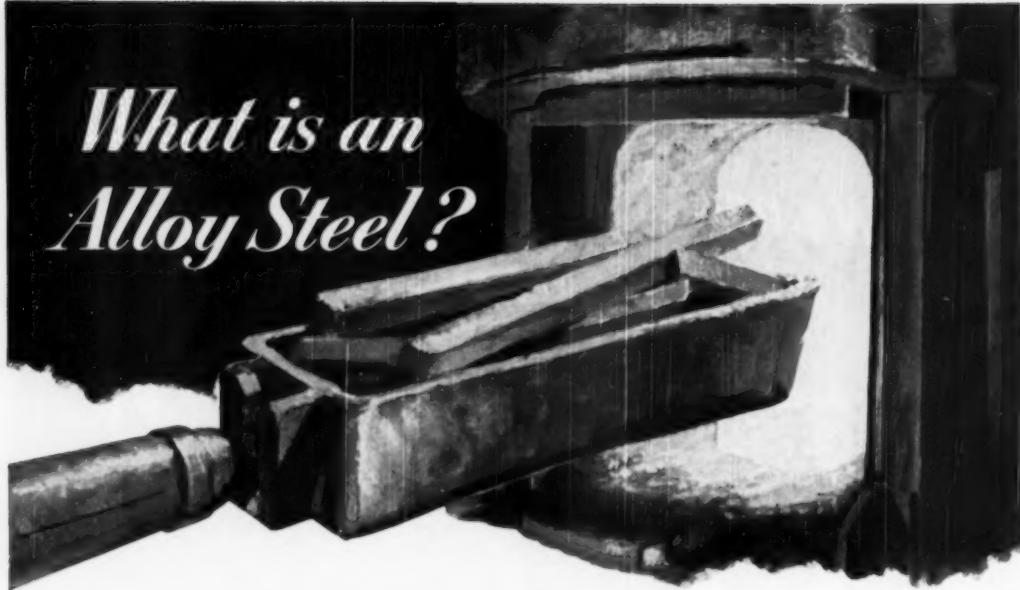
Name

Company

Address

City State

What is an Alloy Steel?



In general, an alloy steel is a grade in which one or more alloying elements have been added to impart special properties and thereby increase the value of the steel for given uses.

More specifically, an alloy steel is defined as one in which the maximum specified content of alloying elements exceeds one or more of the following limits: manganese 1.65 pct; silicon 0.60 pct; copper 0.60 pct — or, one in which there is a range or minimum quantity, within the limits of the recognized commercial field of: aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other element that has been added to produce a desired alloying effect.

WHEN DOES IT PAY TO USE ALLOY STEELS?

Generally, it pays to use an alloy steel when a higher degree of strength, ductility and toughness is required than can be obtained by the use of carbon steel in the section under consideration. Alloy steel should also be employed where such additional properties as resistance to corrosion, resistance to heat, and desirable low-temperature impact values are required.

With carbon steel, good mechanical properties can only be developed near the surface by proper heat-treatment. Uniform properties throughout the piece are possible only when the section of steel is relatively small.

In some instances it may require considerable study to determine when and how to use a particular alloy steel to advantage in a given product. When this is the case, our metallurgists will be glad to give impartial advice on analysis, heat-treatment, machinability and expected results.

We manufacture the entire range of AISI grades and special-analysis steels as well as carbon steels.

**BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.**

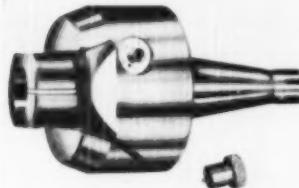
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation—Export Distributor: Bethlehem Steel Export Corporation



BETHLEHEM *ALLOY* STEELS

Engineering Digest of New Products

INTERMEDIATE SIZE BORING HEAD: An intermediate size offset boring head is now being marketed to supplement the other sizes of boring heads now manufactured by Everede Tool Co.



The new size No. 3-50 boring head is $3\frac{1}{4}$ in. in diameter and has a maximum boring capacity of $4\frac{1}{4}$ in. When equipped with an extension attachment it is possible to increase this capacity 100%. Containing the versatile features of both the smaller and larger models, the No. 3-50 boring head has been developed for use in popular size vertical mills, jig boring machines, and turret lathes. For further information circle No. 1021 on literature request card on p. 672B

GEAR HARDENING MACHINE: New radio-frequency gear hardening machine, for high-production heat treating of gears, is available from Westinghouse Electric Corporation. This machine—the Inductall—is used with a vacuum-tube radio-frequency generator, a 10,000-cycle motor-generator set, and other associated equipment, to harden spur gears, cluster gears, integral spindle gears, and also shafts. The machine carries each gear through an automatic cycle for either through- or contour-hardening. Uniformity of hardening results from the mechanical gear handling system and precise electrical timing of the pre-heat, heat-treat, and quench operations. The Inductall system meets increased production requirements. It is simple to operate and maintain, and does not require skilled labor for operation. For further information circle No. 1022 on literature request card on p. 672B

POWDER METAL PRESS: New 8-5 40-ton powder metal press is a cam-operated unit for the production of electric motor, radio, and television parts, machine parts, cemented carbides, porous bearings and other powder metal pieces. New design, offered by F. J. Stokes Machine Co., largely eliminates the necessity for changing cam inserts and changes in set-up are accomplished in a fraction of the time formerly required. A single hand wheel adjustment sets the machine for the proper compression level of the lower punch, automatically taking care of the ejection level by this single setting.

The press may be used for sizing or coining as well as for forming through the use of a special attachment. When used as a sizing press, the parts may be fed either by hand or automatically at full speed.

For further information circle No. 1023 on literature request card on p. 672B

COPPER CLEANING SHOT: New copper cleaning shot, specially designed for the nonferrous trade has just been announced by the Harrison Abrasive Division of Metals Disintegrating Co., Inc.

The manufacturer claims that this new product solves the cleaning problem of those who cast and finish in brass and bronze. L/D Copper Cleaning Shot, as the new shot is called, cleans the casting by the force of its impact, yet does not imbed itself. Thus, it becomes possible to obtain the fine finish which results from "working" the surface of the casting without cutting it. It can be used either in an air or wheel-type machine and for all types of nonferrous castings and pieces. In addition to its use with brass and bronze, it is also very effective when used for blasting aluminum pieces in order to obtain a uniform finish. While designed specifically for the nonferrous casting trade, it is also applicable to all types of cleaning and finishing where a light finish is desired.

For further information circle No. 1024 on literature request card on p. 672B

NEW ELECTRIC CONTROL: New control system just announced by Leeds & Northrup Company—P. A. T. '50—introduces rate action into an electrically-actuated control. The significance of rate action is that it responds according to the speed with which the controlled variable changes—and thus improves process output by reducing the length of time that an upset can force the controlled process off its set point.

If furnace temperature, for example, begins to fall, rate action immediately opens the fuel valve. The faster the drop in temperature, the wider the valve is opened. And as the rate of temperature departure decreases, rate action's effect also decreases—"putting on the brakes" to bring temperature smoothly back in line.

Like the previous L&N model, P.A.T. '50 also has proportional and reset control actions, and is applicable to the regulation of temperature, pH, chemical concentration and gas analysis.

For further information circle No. 1025 on literature request card on p. 672B

CENTRIFUGAL CASTINGS: New equipment to produce larger sizes has been added to the centrifugal casting department at American Non-Gran Bronze Co. The company now offers centrifugally-cast liners,



sleeves, rolls, rings, bushings, etc., in bronze alloys—rough or machined—up to 12 in. O.D. and 13 in. in length. For further information circle No. 1026 on literature request card on p. 672B

SPECIFY
dy ✓ **chek**
dye penetrant
metal inspection

Simplified
Non-Destructive
Testing...
Any Metal—
Anywhere

FASTER,
CHEAPER,
MORE ACCURATE

Completely
Portable,
License-Free

Write
for
Details

dy ✓ **chek**
COMPANY

Division of
Northrop
Aircraft, Inc.

1523 EAST BROADWAY
 HAWTHORNE, CALIF.

Engineering Digest of New Products

METALLOGRAPH: A radically new and improved metallograph is announced by American Optical Company, Instrument Division. Designed as a routine control instrument, it offers superior optical performance together with convenience and simplicity of operation.

This new instrument represents a progressive step in the field of metallography. All controls and adjustments are within easy reach. Directly in front of the operator are the 5 x 7-in. camera, the monocular or binocular microscope eyepieces, and the ball-bearing mechanical stage. Within easy reach is the electrical control panel for the arc and visual lamps. The four objectives on rotating turret, the photographic eyepieces mounted on a quick-change slide, the camera shutter and the color filters . . . all are operable from a sitting position.

The optical systems for photography and visual observations are coupled to permit all focusing to be done through the visual system, eliminating the necessity for ground glass focusing.

Grain size measurements, ferrous or nonferrous, are compared directly on the ground glass with standard grain size charts. Case depth and linear measurements are easily and accurately made with an accessory micrometer rule. Selection of magnification is a very rapid procedure. No

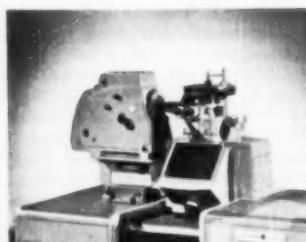
be selected to suit individual needs. The metallograph is equipped with a standard Graflex camera back using inexpensive double plate holders. The photographic eyepieces, on a quick-change slide, are especially designed for optimum photographic results.

For further information circle No. 1027 on literature request card on p. 672B



SAND WASHER: The recommendations of the Committee on Foundry Sand Research of the American Foundrymen's Society for the determination of the clay content of foundry sands call for the agitation of the sand in water and the removal of the clay which remains suspended in the water. All the various steps required in the method are easily taken care of by the new sand washer brought out by the Claud S. Gordon Company. This washer employs a centrifugal unit to remove the clay from the sand grains. A single-blade impeller driven at high speed by an electric motor throws the sand grains against baffles suspended in the beaker containing the sand and water. A siphon with the inlet exactly 1 in. from the bottom of the beaker is used to remove the wash water from the beaker. The siphon action is started by first compressing the rubber bulb and then closing the outlet end of the tube with one finger and releasing the bulb. The washer is available in two models—a single-unit washer with one graduated Pyrex beaker; and a six-unit washer with six beakers.

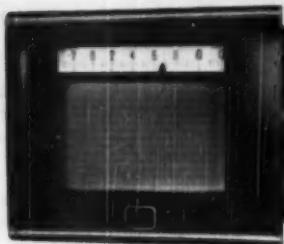
For further information circle No. 1028 on literature request card on p. 672B



tables or charts are required. The objective, eyepiece and camera bellows setting are all identified by the standard A.S.T.M. magnifications. These range from 50 to 1500 \times with 2000 \times available on special request. Monocular or binocular bodies are available. A built-in visual lamp reduces the use of the arc lamp to photography only. Either a ribbon filament tungsten lamp or fully automatic motor-driven arc lamp may

Engineering Digest of New Products

STRIP-CHART ELECTRONIC INSTRUMENTS: The Bristol Company announces the development of a new



line of strip-chart electronic instruments, described as the Series 500 Strip-Chart Dynamaster Electronic Instruments. The Strip-Chart Dynamaster is a high-speed, self-balancing a-c bridge designed for measurement of temperature, resistance, conductivity, strain, position, inductance, pressure, force, or any other variable which can be measured in terms of impedance. In addition, the instrument can be used for electric power totalization and as the receiver for Bristol's Metameter System of Telemetering.

The measured variable is recorded on a chart 11 1/4 in. wide and indicated on a large scale which is legible at a distance. In addition to the single-record model, instruments are available for as many as 16 different records on the same chart.

For further information circle No. 1029 on literature request card on p. 672B

METALLOGRAPH: Bausch & Lomb Optical Company announces a new metallograph. This new Balphot Metallograph provides equipment that combines the economy of more limited capacity instruments with many of the performance advantages of the most advanced metallographs.

These are some of its outstanding features: *straight-line observation*—the Magna-Viewer screen, stage, microscope and eyepiece are all in one line, for easy direct observation. *Centralized controls*—All controls are within easy sight and reach of seated operator. *New fine adjustment mechanism*—Raises and lowers stage 0.1 mm per revolution of fine adjustment knob; knob is graduated to measure

travel; ball bearings provide smooth, backlash-free motion.

Another new feature is the Magna-Viewer, which provides screen images with good contrast and uniform brightness. Use of the screen eliminates the fatigue of prolonged eyepiece observation, resulting in better, faster work in such operations as grain size determination and dirt counts.

For further information circle No. 1030 on literature request card on p. 672B

features which have been incorporated after extensive research in both the laboratory and the field. Some of



DETERMINATION OF CARBON-BY-COMBUSTION: Announcement has been made of the availability of the Combustron, new electronic instrument for rapid and accurate determination of carbon-by-combustion. Offered by Burrell Corporation, the Combustron is a compact, bench-mounted, self-contained instrument; it comes fully equipped, ready to plug into the power supply. It employs induction heating and has exclusive

these features are: instant heating, rapid analysis, visible combustion, a sturdy Vycor reaction tube, and availability in one or two-tube models. For further information circle No. 1031 on literature request card on p. 672B

Full Range of Steels Every Day at FLANNERY BOLT CO., Pittsburgh

One furnace for all heat treating jobs is well demonstrated by another enthusiastic Delaware user. Every day the Flannery Bolt Co. runs the full range of tool steels from carbon to high speed in their quick-heating Delaware Furnace. There is no de-carburization and work is completely scale-free due to the simplified controlled atmosphere system. You can confidently and economically heat treat in your own shop with the easy-to-operate Delaware Furnace. INFORMATIVE DATA is in 16-page Bulletin F-1. Send for your copy.

DELAWARE TOOL STEEL CORP.
WILMINGTON 99
DELAWARE

DELAWARE
Controlled Atmosphere
FURNACES

* * * STRAIGHT FACTS on Controlled Atmosphere are included in DELAWARE BULLETIN F-1.

Send for your copy today.

DELAWARE TOOL STEEL CORPORATION
WILMINGTON 99, DELAWARE



Many years ahead of the field
— the NEW  DESK-TYPE METALLOGRAPH



IN SIMPLICITY of operation, speed, and assurance of perfect results—the new AO Metallograph is years ahead. It is sure to encourage better quality and greater uniformity of photomicrographs.

This revolutionary metallograph for routine control work permits you to

SIT COMFORTABLY AT A SPACIOUS DESK. From start to finish you need not budge from your chair.

FOCUS AUTOMATICALLY AND ACCURATELY... while examining specimen through microscope eyepiece.

MEASURE DIRECTLY ON GROUND GLASS VIEWING SCREEN. Accurate grain size, case depth, and linear measurements made rapidly with comparison chart.

CHANGE OBJECTIVES RAPIDLY. Revolving turret accommodates four objectives.

TAKE NOTES. Desk provides ample writing and storage space.

USE PHOTOGRAPHIC LAMP FOR EXPOSURES ONLY. Built-in illuminator for visual observations, choice of arc or ribbon filament photographic lamp.

DETERMINE ALL OPTICAL SETTINGS INSTANTLY. No charts or tables needed. Identify by ASTM magnification 50X to 1500X.

BUILT-IN PHOTOGRAPHIC EYEPICES QUICKEY SELECTED. Four eyepieces, especially designed for finest photographic results operate in quick-change slide.

ADJUST ARC LAMP EASILY AND QUICKLY. All adjustments are within easy reach on automatic, motor-driven arc lamp—crater imaged on ground glass window.

USE EITHER MONOCULAR OR BINOCULAR BODIES. Both are available, both function with automatic focusing.

This radically improved metallograph is designed and manufactured with typical American Optical Company precision and quality. The infinity-corrected "Apergon" objectives are designed for maximum image contrast. "Americote" optical surfaces are used throughout. A unique pellicle reflecting unit in the vertical illuminator gives increased light transmission. Husky construction and factory adjustment mean years of trouble-free operation.

Learn more about the new AO Metallograph. For a complete 12-page catalog write Dept. L119.

Manufacturers and designers
of precision industrial
optical instruments

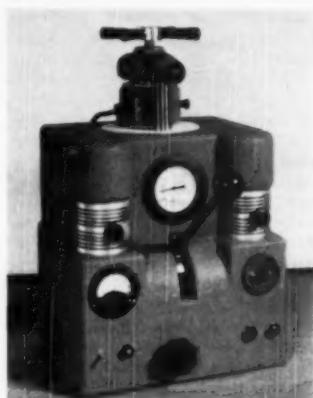
American  Optical

INSTRUMENT DIVISION • BUFFALO 15, NEW YORK

New Products

SPEED PRESS: New No. 1330 AB speed press announced by Buehler, Ltd., is the result of long and exacting experiments to provide the metallurgist with a new tool for the speedy and practical preparation of mounted specimens in either opaque Bakelite or the crystal clear plastic compounds.

Besides the streamlined modern design of this new AB press of 10,000-lb. capacity, the accessories such as molds, heating and cooling blocks are quickly interchangeable for the various size requirements. This new press is not restricted to opaque thermosetting Bakelite compounds; it is equally practical for the preparation of crystal clear thermoplastic AB Transoptic specimen mountings.



The AB speed press is arranged for interchangeable use of hardened stainless steel mold assemblies to produce 1, 1 1/4 and 1 1/2-in. mountings. A model of higher capacity can be provided for larger requirements. This hinged press head is supplied with a semi-automatic lock and a hand wheel screw to lock the mold securely.

The heating blocks are arranged with a magnetic closure to snugly envelop the mold assembly. The interchange of thermostatically controlled heating units of 600-watt capacity for the various size molds is facilitated by convenient supports. The cooling blocks are located in a practical position in front of the AB speed press cabinet.

For further information circle No. 1032 on literature request card on p. 672B



"Gulf L.S. Cutting Base

replaced **3** other oils for gear hobbing
— and does a better job" says this Foreman

"We formerly used three different cutting oils in our gear hobbing department," says this Foreman. "Now we use only one on all machines—Gulf L.S. Cutting Base. It's doing an excellent job—we're getting better finishes and in some cases have been able to increase production. And of course our storage and handling problem has been simplified by elimination of two cutting oils from our inventory."

A typical report from the scores of plants which have made some improvement in machining practice through the use of Gulf L.S. Cutting Base, the outstanding multi-purpose cutting fluid.

Call in a Gulf Lubrication Engineer today and let him help you find opportunities for greater production at lower cost through the use of one

or more of the quality cutting oils in Gulf's complete line. Write, wire, or phone your nearest Gulf office.

Gulf Oil Corporation • Gulf Refining Company

GULF BUILDING, PITTSBURGH, PA.
Sales Offices - Warehouses
Located in principal cities and towns throughout
Gulf's marketing territory





2 NEW COMPACT KEMP ATMOSPHERE GENERATORS OFFER PUSH BUTTON STARTING, FOOL-PROOF OPERATION

If you need a compact source of atmosphere gas, save time and money, specify Kemp! Two new Kemp Atmosphere Generators (models MIHE-1 and 2) deliver 1000 and 2000 cfm respectively. Both offer all features of larger equipment: push button starting, automatic fire check, flow meter, etc., and assure that you get same analysis gas from 1% to 100% of capacity.

FOOL PROOF OPERATION

Kemp Generators burn ordinary gas just as it comes from the mains. A famous Kemp Carburetor, part of each installation, assures complete combustion without "tinkering" to produce

a clean, chemically inert gas containing 88% nitrogen, 12% CO₂ . . . a gas so pure it is used without further processing in copper annealing and in the manufacture of aspirin and laboratory chemicals, fine paints and a host of other products.

WRITE FOR DATA

Whether you need inert for purging, fire protection . . . blanketing or any steel application . . . specify Kemp. For technical information write for Bulletin 1-11. To find out how you can benefit: Tell us how you produce atmosphere gas now; we'll show you how Kemp can solve your problem. Mail Coupon today!

KEMP

ATMOSPHERE GAS GENERATORS

OF BALTIMORE

CARBURETORS
BURNERS
FIRE CHECKS
ATMOSPHERE GENERATORS
ADSORPTIVE DRYERS
METAL MELTING UNITS
SINGEING EQUIPMENT
SPECIAL EQUIPMENT

THE C. M. KEMP MFG. CO., Dept. D-11
405 E. Oliver St., Baltimore 2, Md.

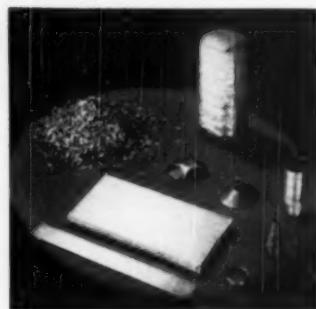
Gentlemen: Send me information on Kemp Generators. I am interested in Bulletin 1-11; data on larger equipment.

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

New Products

NEW STRUCTURAL METAL: A high-purity, ductile vanadium metal is now available in limited quantities for fabrication and use by the metal industry, it has been announced by Electro Metallurgical Division of Union Carbide and Carbon Corporation. The metal averages above 99.8% vanadium and can be obtained in the form of ingots, bars, sheet, and foil. It is also available in the form of chips for remelting into ingots of special sizes and shapes.

Pure vanadium has good corrosion resistance, high tensile strength and excellent ductility. It is highly resistant to corrosion by salt spray, sea water and reducing acids in moderate concentrations, and tests to date indicate that it has good anti-fouling characteristics.



Vanadium ingots can be hot-rolled at temperatures between 1475 and 2100°F. Rolling practice, with respect to passes and reduction, follows that established for austenitic stainless steels. Sheet bar stock does not work-harden appreciably even during cold-working and may be rolled to a sheet having a thickness of 0.020 in. In fact, a reduction of 85% can be made without intermediate annealing.

The machinability of vanadium is about the same as that of cold-rolled steel. The metal is free-cutting and can be machined more readily than nickel, stainless steel, and titanium.

Vanadium metal has good workability and may be formed, bent, stamped, and pressed in the usual manner. For example, the Belleville-type springs shown were made in a simple lead-lined die. Vanadium may be welded by the Heliarc process using an argon atmosphere.

For further information circle No. 1033 on literature request card on p. 672B

1034. Abrasive, Cleaning

Bulletin 59 describes newly developed abrasive for blast cleaning. Tru-Steel Shot, a tough, hard, full heat treated abrasive that provides longer wear life and improved product finish. *American Wheelabrator Co.*

1035. Abrasive Wear

Six-page bulletin, "How to Reduce Abrasive Wear with Thermalloy HC-250", describes the physical properties of the thermalloy HC-250 and lists the many uses and advantages of this exceptionally abrasive-resistant metal. *Electro Alloys Div.*

1036. Alloy Casting Booklet

A new two-color 16-page booklet No. 112 describes the use of heat-resistant, corrosion-resistant, and abrasion-resistant alloy castings, and includes descriptions of properties of many alloys available. Tables and charts show mechanical and physical characteristics in convenient form. *Michigan Products Corp.*

1037. Alloy Handbook

New pocket-size Alloy Handbook. It's a mine of numerous alloy information—and it's yours for the asking. *Riverside Metal Co.*

1038. Alloys

New catalog, "Electromet Ferro-Alloys and Metals", lists over 50 metals and alloys and describes unique technical service offered to the metal industries. *Electro Metallurgical Div.*

1039. Alloys, Fabricated

Catalog available showing cost-cutting fabricated heat treating equipment for higher pay load and better quality. *Rockwell, Inc.*

1040. Alloys, Hardfacing

New 20-page illustrated catalog gives detailed information on the complete Airco line of hard-facing alloys. Includes typical uses, mechanical properties and heat-treatment or recommended procedures. *Air Reduction Sales Co.*

1041. Aluminum

Copy of "Alcos Aluminum Impact Extrusions" will be sent on request, giving full information on impact extrusion process and service. Shows whole range of shapes for engineering. *Aluminum Co. of America*.

1042. Bearing Balls

New booklet, first of its kind, contains practical, authoritative information on use of bearing balls, bushing materials and finishing barrels, in addition to catalog of products. *Abbott Ball Co.*

1043. Beryllium Copper

Helpful engineering information contained in new series of Beryllium copper technical bulletins. *Beryllium Corp.*

1044. Castings

Bulletin FC-350 outlines the many advantages of improved Fahrite corrosion-resistant castings. *Ohio Steel Foundry Co.*

1045. Castings, Steel

New bulletin describes Pyresteel, the chromium-nickel-silicon alloy with prime qualities for resisting oxidation and corrosion up to 2000°F and for withstanding most concentrated or dilute commercial acids and corrosive gases. *Chicago Steel Foundry Co.*

1046. Cast Irons

"Production of Nodular Cast Irons with Cerium" gives valuable information in addition to Cerium to the foundry melt as developed by the British Cast Iron Research Association. First release in America. *Cerium Metals Corp.*

1047. Combustion Chambers, Graphite

M-9602 describes the graphite combustion chambers and "Karbite" impervious graphite burner nozzles. Outlines operation of the complete system and points out the principal features, such as long life, absence of corrosion, minimum maintenance, ability to withstand thermal shock, simplicity and moderate installed first cost. *National Carbon Co.*

1048. Control Devices

New 64-page catalog 3303 illustrates over 100 different industrial control devices for temperature, flow, pressure, liquid level, and humidity. *Brown Instrument Div.*

1049. Copper Sheets

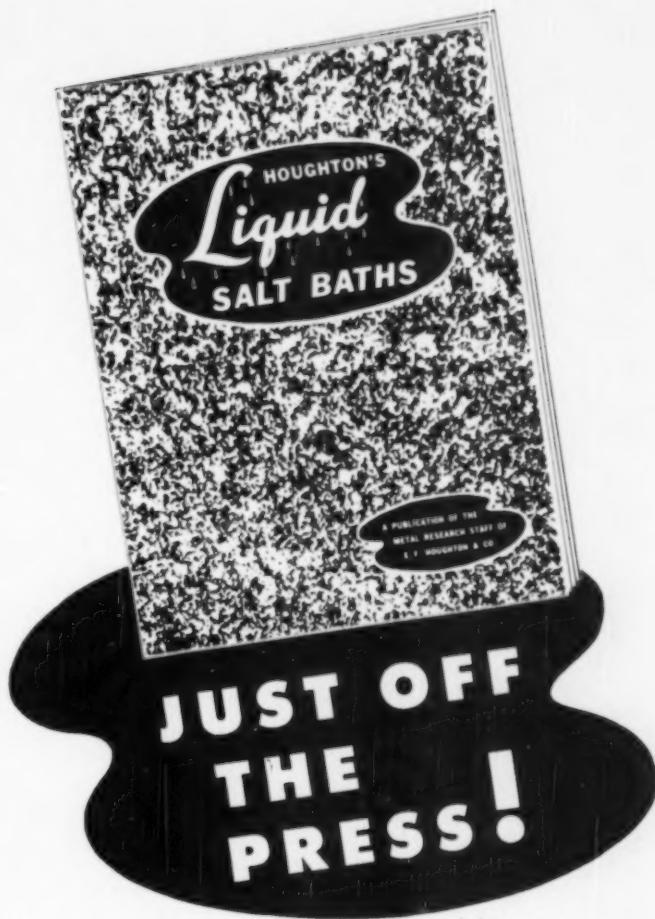
New 23-page booklet, the product of a ten-year program of design, development and tests combined with field investigations, contains complete, detailed specifications for all types of sheet metal installations employing copper. *Revere Copper & Brass, Inc.*

1050. Corrosion

New catalog tells the complete story of industrial rust prevention. Includes three dozen different kinds of services and applications, with an important feature of seventy color chips, for easy identification. *Rust-Oleum Corp.*

1051. Cutting Oils

Write today for the pamphlet, "New Improved Gulf L.S. Cutting Base", which describes how production can be speeded up with lower costs and better finishes by using this newly developed cutting oil. *Gulf Oil Corp.*



Houghton's NEW Salt Bath Book!

A revision of our catalog listing salt bath materials, their properties and uses, has just been completed. It describes salts for carburizing, hardening, annealing, drawing, martempering and treating high speed steel. It tells you why you can "do it better in Salt," based on the experience of Houghton technical men who have long specialized in metal processing. Write E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa., or —

To get your FREE copy
circle No. 1097 on the postcard



1034. Abrasive, Cleaning

Bulletin 59 describes newly developed abrasive for blast cleaning. Tru-Steel Shot, a tough, hard, full heat treated abrasive that provides longer wear life and improved product finish. *American Wheelabrator Co.*

1035. Abrasive Wear

Six-page bulletin, "How to Reduce Abrasive Wear with Thermalloy HC-250", describes the physical properties of the thermalloy HC-250 and lists the many uses and advantages of this exceptionally abrasive-resistant metal. *Electro Alloys Div.*

1036. Alloy Casting Booklet

A new two-color 16-page booklet, No. 112 describes the characteristics of a new, high-temperature-resistant, and abrasion-resistant alloy casting—and includes descriptions of properties of many alloys available. Tables and charts show mechanical and physical characteristics in convenient form. *Michigan Products Corp.*

1037. Alloy Handbook

New pocket-size Alloy Handbook. It's a mine of numerous alloy information—and it's yours for the asking. *Riverside Metal Co.*

1038. Alloys

New catalog, "Electromet Ferro-Alloys and Metals", lists over 50 metals and alloys and describes unique technical service offered to the metal industries. *Electro Metallurgical Div.*

1039. Alloys, Fabricated

Catalog available showing cost-cutting fabricated heat treating equipment for higher pay loads and better quality. *Relock, Inc.*

1040. Alloys, Hardfacing

New 20-page illustrated catalog gives detailed information on the complete Airco line of hard-facing alloys. Includes typical uses, mechanical properties and brief outline of recommended procedures. *Air Reduction Sales Co.*

1041. Aluminum

Copy of "Alcoa Aluminum Impact Extrusions" will be sent on request, giving full information on impact extrusion process and service. Shows whole range of shapes for engineering. *Aluminum Co. of America.*

1042. Bearing Balls

New booklet, first of its kind, contains practical, authoritative information on use of bearing balls, bushings, materials and finishing, barrels, in addition to catalog of products. *Abbott Ball Co.*

1043. Beryllium Copper

Helpful engineering information contained in new series of Beryllium copper technical bulletins. *Beryllium Corp.*

1044. Castings

Bulletin FC-350 outlines the many advantages of improved Fahrite corrosion-resistant castings. *Ohio Steel Foundry Co.*

1045. Castings, Steel

New bulletin describes Pyraseed, the chromium-nickel-iron alloy with prime qualities for resisting oxidation and corrosion up to 2000° F. and for withstanding most concentrated or dilute commercial acids and corrosive gases. *Chicago Steel Foundry Co.*

1046. Cast Irons

"Production of Nodular Cast Irons with Cerium" gives details of actual practice in adding cerium to the foundry melt as developed by the British Cast Iron Research Association. First release in America. *Cerium Metals Corp.*

1047. Combustion Chambers, Graphite

M-9602 describes the graphite combustion chambers—“Kathate”—involving graphite burner nozzles. Outlines operation of the complete system and points out the principal features, such as long life, absence of corrosion, minimum maintenance, ability to withstand thermal shock, simplicity and moderate installed first cost. *National Carbon Co.*

1048. Control Devices

New 64-page catalog 8303 illustrates over 100 different industrial control devices for temperature, flow, pressure, liquid level, and humidity. *Brown Instrument Div.*

1049. Copper Sheets

New 23-page booklet, the product of a ten-year program of design developments and tests combined with field investigations, contains complete descriptive specifications for all types of sheet metal installations employing copper. *Revere Copper & Brass, Inc.*

1050. Corrosion

New catalog tells the complete story of industrial rust prevention. Includes three dozen different kinds of services and applications, with an important feature of seventy color chips, for easy identification. *Rust-Oleum Corp.*

1051. Cutting Oils

Write today for the pamphlet, "New Improved Gulf L.S. Cutting Base", which describes how production can be speeded up with lower costs and better finishes by using this newly developed cutting oil. *Gulf Oil Corp.*

WHAT'S NEW IN MANUFACTURERS' LITERATURE

1052. Electrodes

New 12-page booklet, "The ABC's of Welding High Tensile Steel", guides buyers and users of low alloy, low hydrogen electrodes in seeing the importance and effectiveness of low hydrogen electrodes in welding low alloy, high tensile steels, mild steel under highly restrained conditions, and sulphur-bearing free machining steels. *Arcos Corp.*

1053. Finishes

Full information and samples on Iridite Al-Coat finishes for aluminum surfaces. *Allied Research Products.*

1054. Finishes

Bulletin 1400 tells how the new Hydro-Finish provides cleaner, smoother surfaces prior to coating processes; saves hours on the production line. *Pangborn Corp.*

1055. Finishing

80-page booklet, containing many charts and 68 large illustrations, covers Wear and Surface Finish in nine comprehensive chapters. *Gisholt Machine Co.*

1056. Finishing

New booklet, "Polishing Cloth and Abrasives", furnishes first-hand description and classification of some of the most used but least described accessories in modern sample preparation. *Buehler Ltd.*

1057. Finishing

Alodine coating chemical protects aluminum and its alloys with no plating equipment required. Applied with dip, spray, brush and flow coat, it provides a simple, easy process for lasting, corrosion-resistant finish. *American Chemical Paint Co.*

1058. Forging

New catalog 8 contains 30 pages covering such topics as types of forging; where and how to use forgings; turnbuckle dimensions, strengths and related data. Well illustrated with tables and drawings. *Merrill Bros. Co.*

1059. Forgings

New booklet, "The Improvement of Metals by Forging", gives full details on forgings with controlled directional properties for durability, economy, strengths and machinability. *Steel Improve-ment & Forge Co.*

1060. Free-Machining Bar Steel

Reprint of article entitled "La-Led. A New Free-Machining Bar Steel" by Glenn D. Bayer, metallurgist at LaSalle Steel, discusses the advantages and characteristics of the new steel. *LaSalle Steel Co.*

• If mailed from countries outside the United States
amount of postage stamps must be affixed for return

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

4c POSTAGE WILL BE PAID BY—

METAL PROGRESS

7301 Euclid Avenue

CLEVELAND 3, OHIO

Atmosphere
inciple and simplified
m of the Delaware
trated in new bulletin
of controlled atmos-
and die work. *Del-*

Heat Treating
oment in heat treating
re ranges from 250 to
chnical data bulletin.
ing Co.

als for increased pro-
cipitating furnaces.

described in bulletin
carburizing, nitriding,
ing and clean harden-

able Iron Annealing
graphic description and
s furnace, and also
a gas generator for
able annealing. *Hol-*

g available describing
es designed primarily
n and alloy steels and
ing furnaces for salt.
Charles A. Hones, Inc.

strated catalog on
Describes the triple-
ing atmosphere, and
use of fluid pump
p Co.

Hardening
y of the H.S.S. Hard-
le, economical heat
ng costs and increase

ator
how fully automatic
e, rated 1000 c.f.h.,
g and assures precise
range. Ratio control
atural, propane, butane
mp Mfg. Co.

ay Iron specifications
containing a resume
ay iron specifications
M A-159-47 to ASTM
of two new specifica-
tions 113 and 114.

ed States, proper
or returning card.]

FIRST CLASS
PERMIT No. 1508
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

D
...

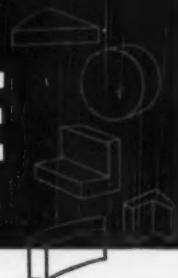
OHIO

CAST SPECIAL SHAPES QUICKLY...EASILY

...with these

FIRECRETE

Castable Refractories



Check the job to be done and you will find a Firecrete* product that will do it well. For special refractory shapes or linings it's simply mix and cast. The new shape or lining air-hardens and is ready for service within 24 hours. Other advantages include—no drying shrinkage, negligible firing shrinkage, high resistance to spalling.

For use up to 3000F—3X FIRECRETE

This new member of the Firecrete family effectively withstands soaking temperatures up to a full 3000F. Provides savings through longer life and reduced shutdowns.

For use up to 2800F—H-T FIRECRETE

A high heat-duty refractory composed of an exceptionally heat-resistant base. Specially developed for service between 2400F and 2800F.

For use up to 2400F—STANDARD FIRECRETE

The most generally applicable type of Firecrete. Finely ground, permitting casting of shapes or linings as thin as 1½".

For use up to 2400F—L-W FIRECRETE

A lightweight insulating refractory concrete with unusually low thermal conductivity, low heat storage capacity and high resistance to spalling.

The above Firecrete materials can be used in combination where varying temperature and service conditions are encountered.

For patching and gunning, use 3X BLAZCRETE. For temperatures to 3000F. It has exceptional adherence qualities, can be flipped into place with a trowel without ramming or tamping.

For further information, write to Johns-Manville,
Box 290, New York 16, N. Y.



© 1958, U. S. Pipe Co.

Johns-Manville
FIRECRETE

"The Standard in Castables"

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

1071. Heating Elements, Electric

Bulletin If gives detailed information on AT-type nonmetallic electric heating elements, including tables for a wide variety of sizes available. *Globar Div., Carborundum Co.*

1072. Heat Treating

Barrett standard anhydrous ammonia is available in 150, 100, and 50-pound cylinders in conveniently located stock points. Send for literature. *Barrett Div., Allied Chemical & Dye Works.*

1073. Heat Treating

Bulletin SC146 outlines an improved process using a time-temperature program control for annealing, quenching and other parts. Radiant tube-fired and direct-fired furnaces are fully described and illustrated. *Surface Combustion Corp.*

1074. Heavy-Duty Forgings

16-page booklet on "Heavy-Duty Forgings", profusely illustrated, shows forgings of all sizes in every phase of development from ingot to finished product. *A. Finkl & Sons Co.*

1075. Heavy-Duty Oils

New 12-page illustrated booklet tells how Sunvis H.D. oils help keep machinery clean, prevent rusting, do not gum up, and provide longer service life in circulating and hydraulic systems, compressors, and gear boxes. *Sun Oil Co.*

1076. Induction Heating

More economical production made possible through redesign of heat treating methods. Full details on application to individual plants furnished in booklet, "A Tocco Plant Survey—Your Profit Possibility for 1950". *Ohio Crankshaft Co.*

1077. Induction Heating

Bulletin 1440 furnishes full details on the "Checklist" system for safety control through the use of oversized components built into every unit for longer service life and uninterrupted production. *Lindberg Engineering Co.*

1078. Induction Heating

Send for bulletin 13-A containing countless new ideas to make tough forging specifications seem easy. *Ajax Electrothermic Corp.*

1079. Lubricants

Interesting facts on how shop operation can be more efficient and economical through the use of right lubricants described in "Metal Cutting Fluids". *Cities Service Oil Co.*

1080. Lubrication of Hot Metals

New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal forming operations. *Acheson Colloids Corp.*

1081. Machine Design

Fundamentals of producing low-cost machine parts—design, material and treatment—are discussed in new 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

1082. Metallograph

12-page catalog describes this completely new all-in-one desk-type unit for metallographic work. *American Optical Co.*

1083. Metal Spinning

New Spincrete data book—a valuable reference bulletin that illustrates lower costs made possible through pioneering developments in working of metals. *Spincrete, Inc.*

1084. Microcastings

This 16-page booklet describes many applications for microcastings and also explains the process itself. *Microcast Div., Ascasol Laboratories.*

1085. Microscopes

Catalog D-1010 illustrates and describes new E series microscopes for the most exacting research work. *Bausch & Lomb Optical Co.*

1086. Oil Quenching

Catalog V-1146 gives detailed information on self-contained oil coolers, together with easy selection tables. *Bell & Gossett Co.*

1087. Oils, Cutting

For the right combination to suit your specific requirements, write for the booklet, "Cutting Fluids for Better Machining". *D. A. Stuart Oil Co.*

1088. Organic Solvents

64-page handbook packed with information including hundreds of definitions, comparison tables, testing methods and product descriptions on a wide variety of organic solvents in common use. Pocket size for easy reference. *The Solvents & Chemicals Group.*

1089. Plating Generators

For electropolating, anodizing, electrocleaning or electropolishing in either large-scale or small operations, there's a Columbia M-G set available for you. Catalog MP-700 sent free on request. *Columbia Electric Mfg. Co.*

1090. Polishing Machine

As a result of continued demand, the new 484 Duplex Polishing machine has been developed for quality finish on small cylindrical work. Equipped with two polishing heads, it employs the use of abrasive, felt, leather or fabric belts, depending on finish desired. *Production Machine Co.*

1091. Polishing, Metallographic

For preparation of fine metallographic specimens, a sturdy, smooth-operating table-model metallographic polisher is described in bulletin 90. *Eberhard & Son Co.*

1092. Pyrometer

Catalog No. 80 illustrates and describes the Pyro Optical Pyrometer for quick, accurate temperature readings on minute spots, fast-moving objects and small streams in a temperature range from 1400°F to 7500°F. *The Pyrometer Instrument Co.*

1093. Quenching Oil

New technical bulletin describes triple-action quenching oil. Accelerators provide deeper hardening and reduced distortion. *Park Chemical Co.*

1094. Refractories

Complete details on refractory cements for every masonry and metal application are available in catalog 863. *Norton Co.*

1095. Rolling Mill Machinery

New 30-page rolling mill machinery catalog covers machinery for blooming, slabbing and billet mills; merchant mills; steel plate mills; flat and coil mills; sheet and strip, plate mills, tubes and pipe mills; rail mills and special custom-built equipment. In addition, it contains diagrammatic layouts showing the design and construction of complete mills. *Bardboro Steel Foundry & Machine Co.*

1096. Rust Preventives

Two new transparent rust preventives, which replace heavy, opaque, gummy compounds formerly used for export shipment and the lacquer or varnish coatings, are discussed in new 4-page bulletin on Nox-Rust. Clear Coat 626 and Clear Coat 607. *Nox-Rust Chemical Corp.*

1097. Salt Baths

32-page bulletin entitled "Houghton Liquid Salt Baths" discusses the advantages of this process for tempering, brazing, annealing, hardening, reheating, and carburizing. Also contains many pages of factual heat treating data. *E. F. Houghton & Co.*

1098. Steam Drop Hammers

Prominently-illustrated 24-page brochure describes construction of steam drop hammers. *Erie Foundry Co.*

1099. Steel, Cold Finished

16-page bulletin entitled "You Can Make Them Better with Cold Finished Jalcase" gives technical information, charts and graphs about Jalcase 10 and the other nine grades of Jalcase. *Jones & Laughlin Steel Corp.*

1100. Steel Selector

Handy, clearly printed, easy-to-use tool steel selector will be furnished on request. *Crucible Steel Co. of America.*

1101. Steel, Stainless Machining

New "Notebook on Machining Stainless Steels" contains a wealth of useful shop hints on turning, drilling, threading, milling, lubrication, etc. *The Carpenter Steel Co.*

1102. Steels, Alloy

New book is now available on the selection of the proper alloy steel grades for each manufacturer's needs. Write for free copy of "Wheelock, Lovelock Data Book". *Wheelock, Lovelock & Co.*

1103. Thermocouples

Catalog 59-R tells complete story about use of Chromel-Alumel couples and extension leads. *Hughes Mfg. Co.*

1104. Thermocouples

New Catalog No. 5 contains full line of pyrometer supplies and buyers' guide showing how to get better control at lower cost by means of these new, easily assembled units for all makes of pyrometers. *Arbly S. Richards Co.*

1105. Tool Steels

To get the best results from your present equipment, send for the new 189-page Carpenter Tool and Die Steel Manual. *Carpenter Steel Co.*

1106. Tungsten and Molybdenum

New 24-page illustrated booklet on tungsten and molybdenum covers metallurgy, physical, mechanical and chemical properties, uses and applications, fabricating techniques and available forms. Of particular new interest are seamless molybdenum tubing and molybdenum parts with protective coatings for high temperature service in air. *Panited Metallurgical Corp.*

1107. Turbo-Compressors

Bulletins available as follows: Data book 107, Gas Boosters 109, Four-Bearing 110, Blast Gates 122, Foundry 112. Descriptive bulletin 127 and Technical bulletin 126. Send for each by number for particular application. *Spencer Turbine Co.*

1108. Valves, Safety

New series "LT" Lock-Tite safety valve making possible instantaneous gas shut-off under any or all unsafe conditions. Described in bulletin M-302. *Editor Fuel Engineering Co.*

1109. Welding

Information available on fast, clean process for welding sheet steel with the Heliatec torch. *Linde Air Products Co.*

1110. Zinc, Coatings

16-page illustrated booklet discusses the origin of galvanizing, the various zinc coating methods employed today and the advantages of zinc as a protective coating for iron and steel products. *St. Joseph Lead Co.*

If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card

METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

November, 1950

Please have literature circled at the left sent to me.

Name	Title
Company	
Products Manufactured	
Address	
City and State	

Postcard must be mailed prior to February 1, 1951—
Students should write direct to manufacturers.

1021	1039	1057	1075	1093
1092	1040	1058	1076	1094
1023	1041	1059	1077	1095
1024	1042	1060	1078	1096
1095	1043	1061	1079	1097
1026	1044	1062	1080	1098
1027	1045	1063	1081	1099
1028	1046	1064	1082	1100
1029	1047	1065	1083	1101
1030	1048	1066	1084	1102
1031	1049	1067	1085	1103
1032	1050	1068	1086	1104
1033	1051	1069	1087	1105
1034	1052	1070	1088	1106
1035	1053	1071	1089	1107
1036	1054	1072	1090	1108
1037	1055	1073	1091	1109
1038	1056	1074	1092	1110



CONTROLLING "NICHROME"** FURNACES IN DRIVER-HARRIS FOUNDRY...

Driver-Harris Company's famous "Nichrome"

and "Nichrome" Σ —leading alloys, used as heating elements in all sorts of products from common toasters to high-temperature electric furnaces—are rigidly controlled from the foundry to the finished wire by spectrographic analysis.

In addition to "Nichrome", Driver-Harris depends upon the spectrograph to maintain the extremely high standard of many other alloys... to speed up operations... to hold analysis costs down. They use "National" spectroscopic electrodes.

Why it pays to use "National" spectroscopic

electrodes. National Carbon's spectroscopic electrodes are the purest obtainable. Each shipment is accompanied by a "Statement of Purity" which tells your analyst what trace elements are present in the electrodes. As a result, he can assess his plates or film very quickly and accurately without being confused by unexpected spectral lines.

*Registered trade-mark of D-H Company

OTHER ADVANTAGES OF SPECTROGRAPHIC ANALYSIS

- Sensitive to 1/10,000,000 of a gram for some elements
- Saves time in analysis
- Detects unsuspected metals
- Accurate testing is possible with very small sample
- Provides a permanent record
- Differentiates between two elements chemically very similar
- Analysis can be made in some cases without destroying sample

The term "National" is a registered trade-mark of
NATIONAL CARBON DIVISION

UNION CARBIDE AND
CARBON CORPORATION
30 East 42nd St., New York 17, N. Y.
District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City,
New York, Pittsburgh, San Francisco



The bundle of sticks

A wise old man called his quarrelsome sons about him. Taking up a bundle of sticks, he commanded each in turn to break the sticks. All tried, but in vain, and said it could not be done.

"And yet, my boys, nothing is easier to do," said the father, as he undid the bundle and broke the sticks, one by one. "By this example, you can see that united you will be more than a match for your enemies; but if you quarrel and separate, your weakness will put you at the mercy of those who attack you."

The useful truth of this fable is just as timely today as it was when the Greek ex-slave

Aesop told it 2,500 years ago. You, a patriot, believing in individual liberty and freedom for all, see our American way of life threatened by the menace of communism abroad and jeopardized at home by complacency, negligence, confusion and incompetence.

As a business leader in your own community, you have a particular responsibility to help unify your fellow citizens and guide their thinking and action--for the strengthening and preservation of the ideals that built America, in fact, made America the envy and goal of the very individuals now seeking to destroy it. *In Union there is Strength.*



The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio

Export Offices--500 Fifth Avenue, New York

MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

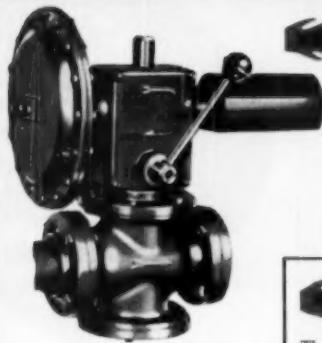
RAILROAD TRACK SPIKES - CONDUIT - HOT AND COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RODS - SHEETS - PLATES.

Specify

McKee
Eclipse

Products You Saw at The Metal Show

Back of every one of these New McKee-Eclipse Products is more than 30 Years Experience with combustion equipment designed for all types of applications and burning any type gas or combination of gases.



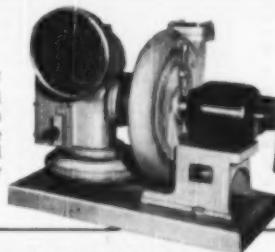
Series "LT" McKee-Eclipse LOCK-TITE Safety Valve

Generally acclaimed as one of the most unusual and important developments in recent years in the industrial gas field! Makes possible for the first time, instantaneous Gas Shut-Off under *any* or *all* unsafe conditions. As a *double* protection, when the gas valve has snapped shut due to an unsafe condition, it must be opened manually, and only after the unsafe condition has been corrected.



McKee Constu-Mix Proportioning Valve

The very latest in a wide selection of McKee Air-Gas Mixers, L-P Proportional Mixers and Diluter Valves. Permits minute adjustment of the air-gas mixture at any point in valve capacity, and independent of pressure or other fluctuations.



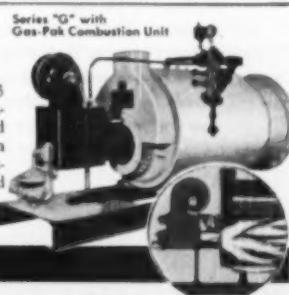
Series "PW" McKee-Eclipse Piloted Wall-Tite Burners

Another remarkable McKee-Eclipse Advancement! A Sealed Burner with Flame Failure Protection and Constant Blast Pilot. Particularly suitable for low temperature applications or where burners are in a "difficult-to-light" location.

Send for
Bulletins on
Products in which
you are interested

Super-Matic Scotch "Steamboilerplants"

These new Scotch Marine Boilers (13 years field-tested) are part of an extensive line of McKee Automatic Gas-Fired "Steamboilerplants" 12 to 100 H.P., in vertical and horizontal models. "Complete package" ready to connect up, and operate at the push of a button.



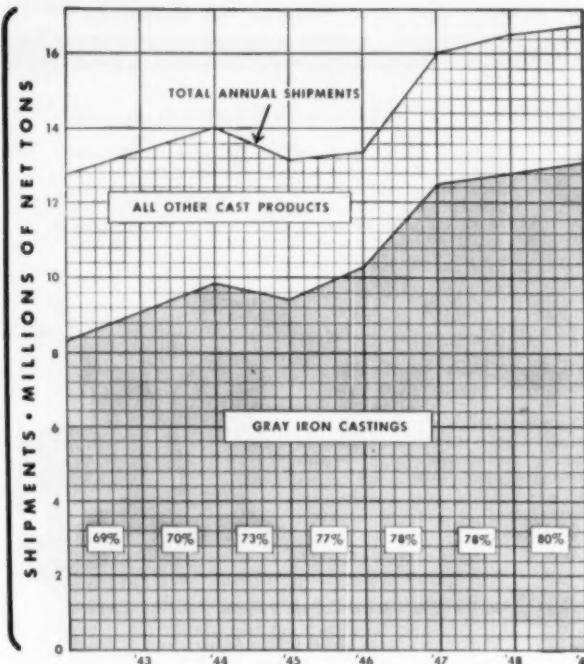
REPRESENTATIVES IN ALL PRINCIPAL CITIES

R 5272R

McKee
Eclipse

Again!

GRAY IRON LEADS THE FIELD



In 1949
GRAY IRON accounted for
80%
 of all cast metal
 products shipped

Note the steady increase in annual shipments of Gray Iron Castings as shown on chart at the left. Gray Iron's percentage of total cast metal products has increased from 69% in 1943 to about 80% in 1949.

Here's factual proof of Gray Iron's constantly increasing acceptance by design engineers, production and purchasing executives throughout industry. The reasons? They're summed up in Gray Iron's unmatched combination of characteristics, including . . . castability, rigidity, low notch sensitivity . . . resistance to wear, heat and corrosion . . . machinability, vibration absorption, durability and wide strength range.

Are you making full use of these advantageous characteristics in your products?

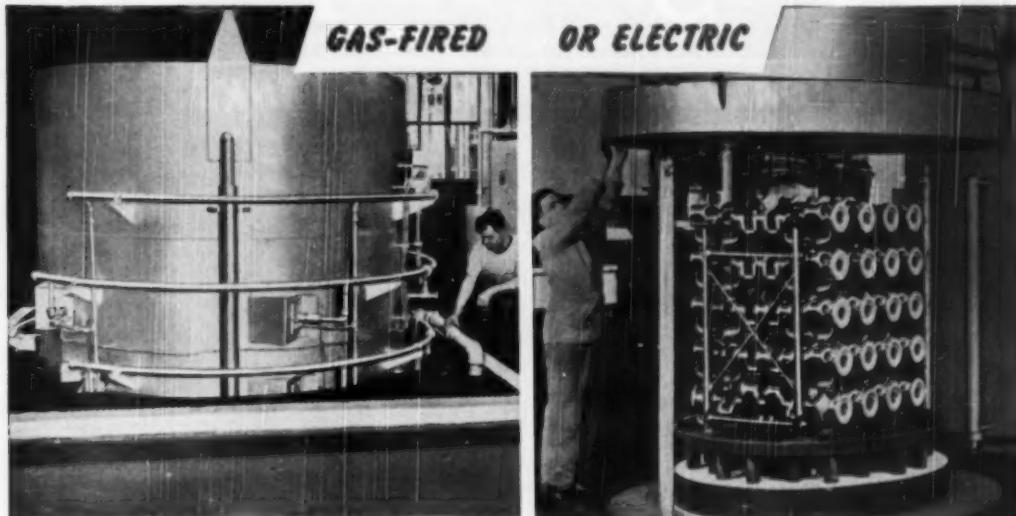
Make It Better with Gray Iron
 Second largest industry in the Metal-working field



GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

YOU CAN BE **SURE**.. IF IT'S
Westinghouse



**FOR THE MAN
WHO CAN'T BE "SOLD"**

Careful buyer? Then, here is help in selecting the equipment to do your job best. You see, Westinghouse makes both electric and gas-fired furnaces, plus the atmosphere equipment that may be required. Thus, Westinghouse engineers have no favorite type of firing or construction to sell. Instead, they study your heat-treating problems with a view toward recommending the equipment to do your job best.

And you can preview results! A well-equipped metallurgical laboratory will sample heat-treat your work and demonstrate the mass production results you may expect.

This unbiased engineering and metallurgical service is called Therm-a-neering. It matches the equipment to your job . . . provides the hundreds of design details that make your heat-treat line run smoothly and economically.

Give Therm-a-neering a chance to help you. You won't have to be sold. You'll know why it's best to buy Westinghouse. Call your nearby Westinghouse representative for details, or write Westinghouse Electric Corporation, 180 Mercer Street, Meadville, Pa.

J-10346

Therm-a-neering. A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.



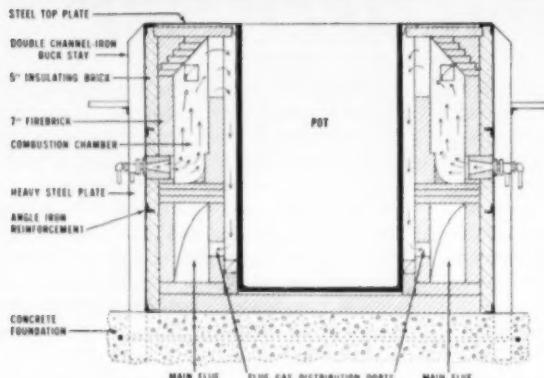
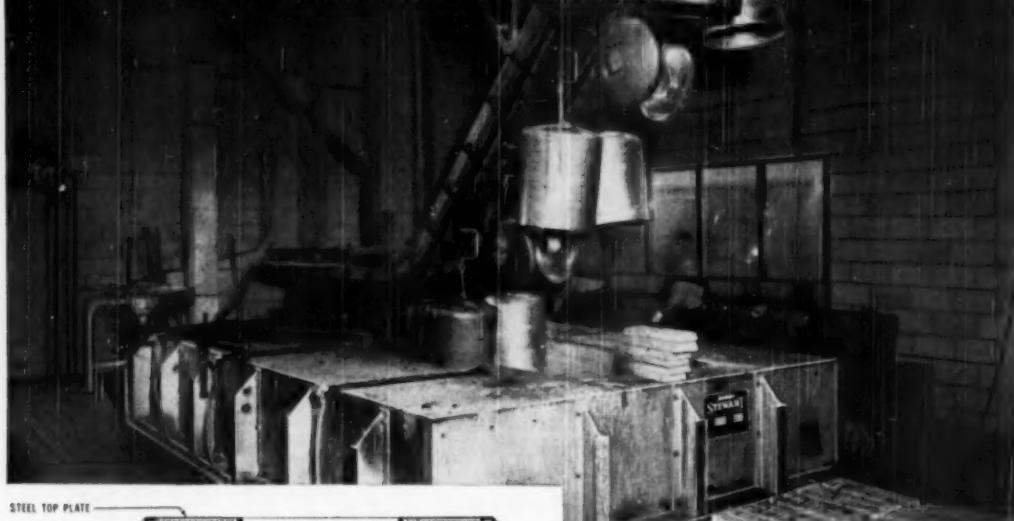
No. 102
of a
Series
of Typical
Installations

Sunbeam
STEWART
THE BEST INDUSTRIAL FURNACES MADE

HOW
SUNBEAM STEWART
FURNACES HELP
MANUFACTURERS
REDUCE COSTS AND
KEEP THEMSELVES
COMPETITIVE

GALVANIZING WATER TANKS

AT HOTPOINT WATER HEATER DIVISION, Milwaukee, Wisconsin



Plan view of the Sunbeam Stewart galvanizing furnace in use at Hotpoint. Note how the fuel is completely burned in a separate combustion chamber and how the hot products of combustion flow evenly up over a dividing baffle wall to the top section of the pot and then down the side to exhaust vents. This design assures:

UNIFORM BATH TEMPERATURE; MAXIMUM PRODUCTION RATE;
LOW DROSS LOSS; LOW FUEL CONSUMPTION AND LONG KETTLE LIFE.

At Hotpoint, water tanks with diameters from 16 to 20 inches and depths from 16 to 60 inches are galvanized in Sunbeam Stewart deep-type Galvanizing equipment. The 8½ ft. depth of the settings presented problems in heat distribution not normally encountered with conventional settings.

The Sunbeam Stewart indirect, high side fired furnace design, together with 20 special nozzle-mixing burners, makes it possible to supply an even quantity of heat to the sides of the kettle. The accurate flame control of the burner gives the desired flame length while still maintaining a sufficient BTU output. The turndown ratio eliminates the need for a second set of burners for idling temperatures.

Improved design and correct engineering have made Sunbeam Stewart the leader for galvanizing equipment. Quality of work and low cost of maintenance and operation are key factors in Sunbeam Stewart's design that have proved their worthiness year after year. Users report dross loss as low as 5% and kettle life up to six years. If galvanizing is important in your manufacturing process, it will pay to consult Sunbeam Stewart. Designs are available for small or large production. We will be glad to submit ideas on how you can get more economical operation.

Sunbeam
STEWART INDUSTRIAL FURNACE DIVISION of *Sunbeam* CORPORATION
(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 108, 4433 Ogden Ave., Chicago 23 — New York Office: 322 W. 48th St., New York 19 — Detroit Office: 3049 E. Grand Blvd., Detroit
Canada Factory: 321 Weston Rd., So., Toronto 9

A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

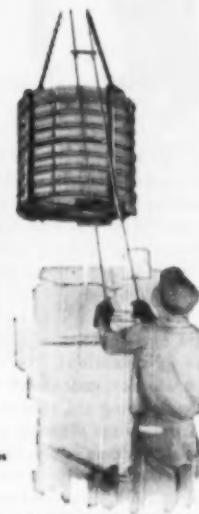
ROLLOCK FABRICATED ALLOYS



Sling lies on floor as trays are filled.



Sling is raised to fit into indentations.



Sling safely holds assembly as it is hoisted to furnace.

3 SLING SHOTS THAT SCORE FOR CRUCIBLE STEEL

The three camera shots above clearly picture the three principal advantages of this fabricated-welded stainless steel tempering assembly. Both Rolock and Crucible Steel engineers contributed to the design which features: (1) a rugged carrier sling, (2) indented trays for close, safe fit of sling, (3) maximum furnace capacity.

The shallow, easy stacking trays separate varied sizes of Alnico permanent magnets and a thermo-

couple is used between the fourth and fifth trays ...with another one on the top. The assembly weighs 665 lbs., maximum load 3200 lbs., a ratio of 4.8 to 1.

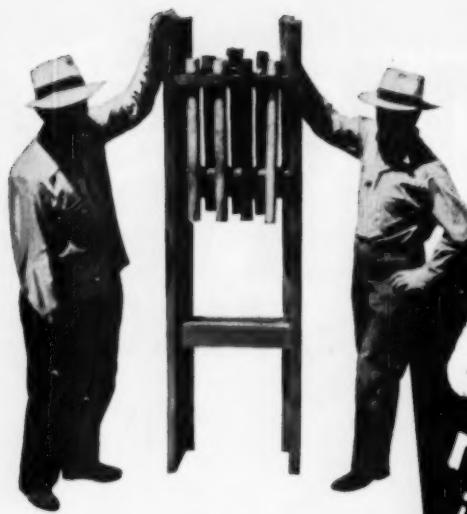
Rolock job-engineered heat treating equipment will speed handling, give you more uniform quality, lengthen service life and reduce work-hour costs. If you have such problems, call our Rolock engineers for practical recommendations.

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

ROLLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

ROLLOCK



The wooden rack assembly supporting the seven pieces undergoing tests in the manhole.

LEAD

rates highest in corrosion test of waste pipe materials

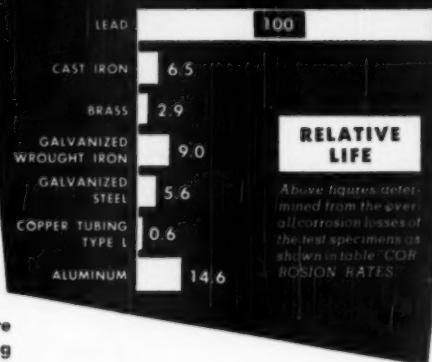
IN A RECENT TEST of various pipe materials used or suggested for soil, waste and vent lines, conducted under accelerated conditions in Fort Worth, Texas, lead pipe proved to be outstanding, having a relative life expectancy of more than six times that of the next closest material tested.

The test specimens were 2 ft. sections of pipe and conformed to established plumbing size specifications. The samples were placed in a wooden rack which was placed in a manhole carrying the return sludge from the Fort Worth sewage disposal plant's aeration basin. The specimens were kept 18 in. above the water line. Analyses showed the sewage to be alkaline, the condensed moisture on the samples acid and the surrounding atmosphere to contain hydrogen sulphide. Although the conditions of the test — being accelerated — were more stringent than usually found in the plumbing system, all of them are present in the ordinary waste system to a lesser degree.

The duration of the test was one year and the table below shows the corrosion rates of the various pipe materials tested.

CORROSION RATES Data from "Comparative Corrosion Study of Soil, Waste and Vent Pipe Materials" by John D. Kane, Chief Plumbing Inspector, Dept. of Public Works, Fort Worth, Texas, presented at the 1949 Annual Convention of the American Society of Sanitary Engineering.

MATERIAL	WEIGHT LOSS OZ. SQ. IN. / YR.	VOLUME LOSS IN. PENETRATION / YR.
LEAD	0.00167	0.000259
CAST IRON	0.02510	0.005540
BRASS	0.04910	0.009660
GALVANIZED WROUGHT IRON	0.01370	0.003022
GALVANIZED STEEL	0.02140	0.004758
COPPER TUBING TYPE L	0.10150	0.019720
ALUMINUM	0.00270	0.001825



Furthermore, lead was the only metal not affected by pitting. All the other materials were pitted in varying degrees with one of the most commonly used competitive metals having pitted completely through the wall of the tubing.

The results of the test prove conclusively that for the conditions encountered in soil, waste and vent lines, lead is, by far, the most enduring pipe material.

ST. JOSEPH LEAD CO.
250 PARK AVENUE, NEW YORK 17

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

SEVEN STRONG REASONS

A better steel for the purpose in hand has always found favor with manufacturers of commercial vehicles . . . currently the trend is to N-A-X HIGH-TENSILE steel.

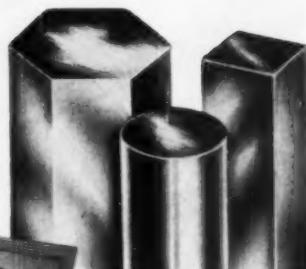


**Tough Machining Problems
Solved with J&L Cold-Finished**

JALCASE 10



**J&L
STEEL**



GET THIS BOOKLET

FREE

You'll want more information about Jalcase 10 . . . and the other nine grades of Jalcase. Our booklet entitled "You Can Make Them Better with J & L Cold-finished Jalcase" contains information and technical data to help you produce better parts. This illustrated booklet is yours for the asking. Write today!



Maybe you haven't gotten the word yet, but more and more machinists are "discovering" Jalcase 10 (A.I.S.I. No. C-1144), the top grade of J&L Cold-finished Jalcase. And they're getting good results, too! Here's why.

Jalcase 10 is the highest carbon grade of Jalcase; it has high mechanical and machinability properties. This makes Jalcase 10 ideal for those tough "in between" machining applications. For instance:

Many times the finished-parts specifications on a job call for a high degree of hardness, but not as high as that obtained through heat-treating the finished part. In these applications, manufacturers and machinists have found it profitable to

use Jalcase 10 and dispense with the heat-treating altogether.

This saves production time and cuts down on costs. And Jalcase 10's high quality produces a better finish. It's worth your while to try Jalcase 10 on your screw machines.

JONES & LAUGHLIN STEEL CORPORATION

From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY and JALLOY (hi-tensile steels).

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

**MAIL THIS
COUPON**

Jones & Laughlin Steel Corporation
405 Jones & Laughlin Building
Pittsburgh 30, Pennsylvania

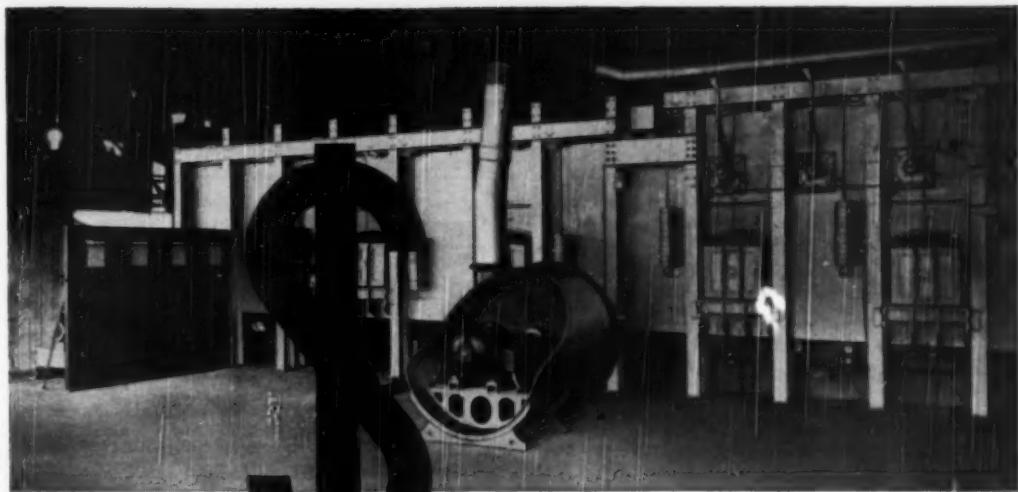
— Please send me a free copy of
"You Can Make Them Better with
J&L Cold-Finished Jalcase".

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____



DOLLAR A YEAR MACHINES!

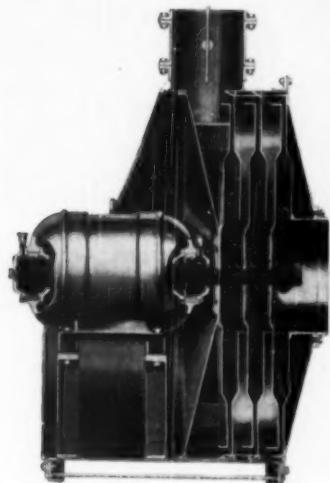
(SPENCER TURBO-COMPRESSORS)

A study of typical plants where Spencer Turbo-Compressors have been in use ten years or more shows less than one dollar per year per machine for spare parts.

The centrifugal design with wide clearances, low peripheral speeds and only two bearings to lubricate is partly responsible for this record.

Original test efficiencies are maintained for the life of the machine. Power is used only in proportion to the load—and efficiencies are high at all loads.

Spencer Turbos have been the preference in heat treating for many years. "Other uses" however have been increasing rapidly. Here are some of the special services that are being rendered by



ASK FOR THESE BULLETINS

TECHNICAL BULLETIN	No. 126
DATA BOOK	No. 107
GAS BOOSTERS	No. 109
FOUR BEARING	No. 110
BLAST GATES	No. 122
FOUNDRIES	No. 112

359-A

SPENCER TURBOS

AGITATION

Electro Plating
Flotation
Sewage
Yeast

GAS BOOSTERS

Atmos Gas Producer
Gas Plants
Premixing Equipment

GAS ENGINE

Testing
Super-charging
Engine Exhaust

VENTILATION AND COOLING

Scale Blowing
Glass Cooling
Mines
Tunnels

MISCELLANEOUS

Glass Blowing
Paint Spraying
Tin Plate Cleaning

Spencer Turbos are standard in capacities from 35 to 20,000 cu. ft.; $\frac{1}{3}$ to 800 H.P.; 8 oz. to 10 lbs. Four bearing, gas tight; single and multi-stage.

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Division, Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

SILICON . . . Deoxidizes, Increases Strength, and Improves Electrical Properties of Metals

Silicon is one of the most important elements used in the iron, steel, and non-ferrous industries. It is an efficient low-cost deoxidizer; and in larger amounts, it is also an effective alloying element.

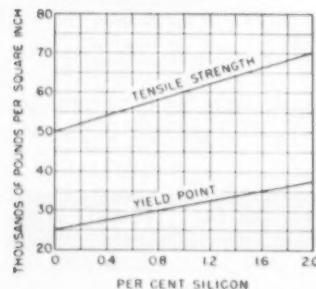
Efficient Deoxidizer

Silicon is used in practically all grades of carbon and alloy steels and offers an economical means of effectively eliminating oxides from the molten bath in all steel-making processes. Amounts up to about 0.80 per cent silicon are used for deoxidizing various steels used for forgings, wrought products, and castings.

Recent published research papers, covering work done in ELECTROMET's laboratories, have added greatly to the knowledge about the deoxidizing power of silicon by itself, and also in conjunction with other elements. Complete information is given in a report entitled "Solubility of Oxygen in Liquid Iron Containing Silicon and Manganese." If you would like a copy of this report, free of charge, write to the address above.

Improves Physical Properties

When used as an alloying element, silicon in small percentages will increase the tensile strength, yield point, and ductility of structural steels, such as those used for highly stressed parts of bridges. Some



Effect of silicon on tensile strength and yield point of a steel containing approximately 0.10 per cent carbon.

spring steels contain about 2 per cent silicon. Another application of silicon as an alloying element is in stainless steels, where it appreciably increases the resistance of these steels to certain types of corrosion and to high-temperature oxidation.

Decreases Watt Loss

Silicon increases the magnetic permeability of steel. Hence silicon steel is specially suited for use as a "core" material in electrical generators, motors, transformers, electromagnets, and other electrical equipment. Because silicon decreases magnetic resistance, silicon steels show much lower eddy current losses. As a result, energy or watt losses are greatly decreased and tremendous overall savings are effected in the generation, transmission, and use of electrical power. Up to 5 per cent silicon is used in sheet steel for electrical apparatus.

Benefits Cast Iron

In cast iron, silicon not only serves as a deoxidizer but also has a marked graphitizing

effect. Silicon tends to soften cast iron, thereby improving machinability and providing a control over depth of chill and physical properties. In larger amounts, sometimes as much as 14 per cent, silicon makes cast iron suitable for handling highly corrosive acids in chemical plants.

Improves Non-Ferrous Alloys

Silicon is used in non-ferrous alloys to increase strength and hardness, and to improve other physical properties. In various aluminum alloys, as much as 18 per cent silicon may be used. Copper alloys, too, frequently contain silicon: for example, the silicon bronzes.

Available Alloys

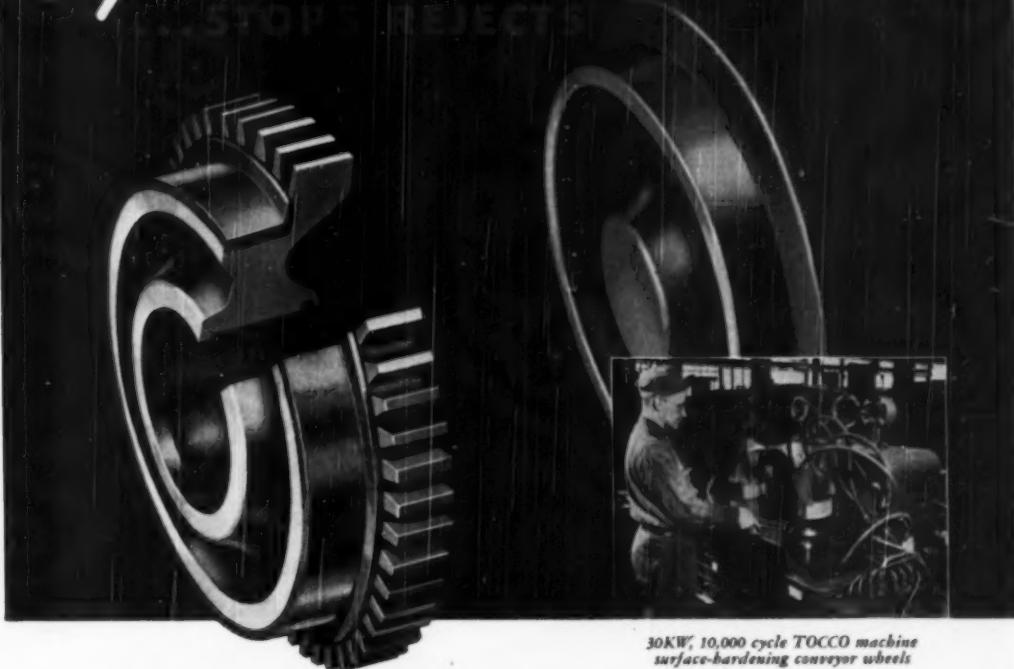
Silicon is produced by ELECTROMET in the forms listed below, which are suitable for every use of the iron, steel, and non-ferrous metal industry. For a complete description of these alloys, write to the address above for a copy of the 100-page booklet, "ELECTROMET Ferro-Alloys and Metals." This booklet describes over 50 metals and alloys produced by ELECTROMET and tells of the unique technical service offered to the metal industries.

The terms "Electromet," "EM," and "SMZ" are trade-marks of Union Carbide and Carbon Corporation.

Alloys of Silicon and Their Uses

15% Ferrosilicon	In ground form, this alloy is used in the "sink and float" process of concentrating ores.
50% Ferrosilicon	Widely used as a deoxidizer; as a furnace block; and for adding silicon to fill specifications in the production of steel. Also used in the production of cast iron.
65% Ferrosilicon	Used mainly in the production of electrical sheet steel. (Available in low-aluminum grade only.)
75% Ferrosilicon	Used both as a deoxidizer and for alloying purposes in the production of steel, particularly steel containing high percentages of silicon. Also used for ladle additions to cast iron.
85% Ferrosilicon	Used for same general purposes as 75% ferrosilicon. Permits large silicon additions without harmful chilling effects.
90% Ferrosilicon	Used for same general purposes as 75% and 85% ferrosilicon. Permits large silicon additions without harmful chilling effects.
Silicon Metal	For use in the non-ferrous industry, particularly in the manufacture of aluminum and copper alloys. Also used to produce the organo-silicon compounds known as silicones.
Purified Silicon Metal	For special applications requiring silicon metal of the greatest purity.
"SMZ" Alloy	For ladle additions in the production of cast iron. Exerts strong graphitizing effect.
"ELECTROMET" Special Graphitizer	For ladle additions in the production of cast iron.
"EM" Silicon Briquettes	For adding silicon to cast iron in the cupola or air furnace.
Silicomanganese	For adding silicon and manganese simultaneously in steel making processes.

Ups output 250%



30KW, 10,000 cycle TOCCO machine surface-hardening conveyor wheels

with TOCCO* Induction Heating

PROBLEM: Cleveland Crane and Engineering Co. hardens the *running surface* of steel drive wheels and idlers used in their tramrail overhead materials handling equipment. Flame-hardening limited their production to only 300 wheels per day—rejects ran as high as 55%!

SOLUTION: A 30KW, 10,000 cycle TOCCO machine to provide speedy automatic heating.

RESULT: Production increased 250%—costly rejects eliminated, a completely automatic "virtually foolproof" operation. The TOCCO machine, in use for two years, has required no maintenance other than regular lubrication!

Like to duplicate this success story? Why not have a TOCCO engineer survey your hardening, brazing, forging or melting requirements for similar cost-cutting results?

THE OHIO CRANKSHAFT COMPANY



NEW FREE
BULLETIN

----- Mail Coupon Today -----
THE OHIO CRANKSHAFT CO.
Dept. R-11, Cleveland 1, Ohio
Please send copy of "A TOCCO
Plant Survey—Your Profit Possi-
bility for 1950".

Name. _____

Position. _____

Company. _____

Address. _____

City. _____ Zone. _____ State. _____

For
**Figuring High
Temperature
Applications
of Stainless
Steel...**

ELEVATED TEMPERATURE PROPERTIES

of Type 321
Titanium Stabilized Austenitic
Chromium Nickel Steel

	TEMP. °F	STRESS-PSI
Creep: 1%—10,000 hrs.	1100	16,000
	1200	11,000
	1300	7,000
Stress for Rupture in 1000 hrs.	1100	32,000
	1200	21,000
	1300	12,000

A. I. S. I. type 321

Titanium stabilized stainless steel offers many competitive advantages at a substantial saving in cost compared to other types of stabilized stainless. The excellent high temperature properties, shown here, are an example. Alloys of Titanium used in making type 321, are made at Niagara Falls from U. S. ores. This assures the user a plentiful supply of type 321 stainless steel.

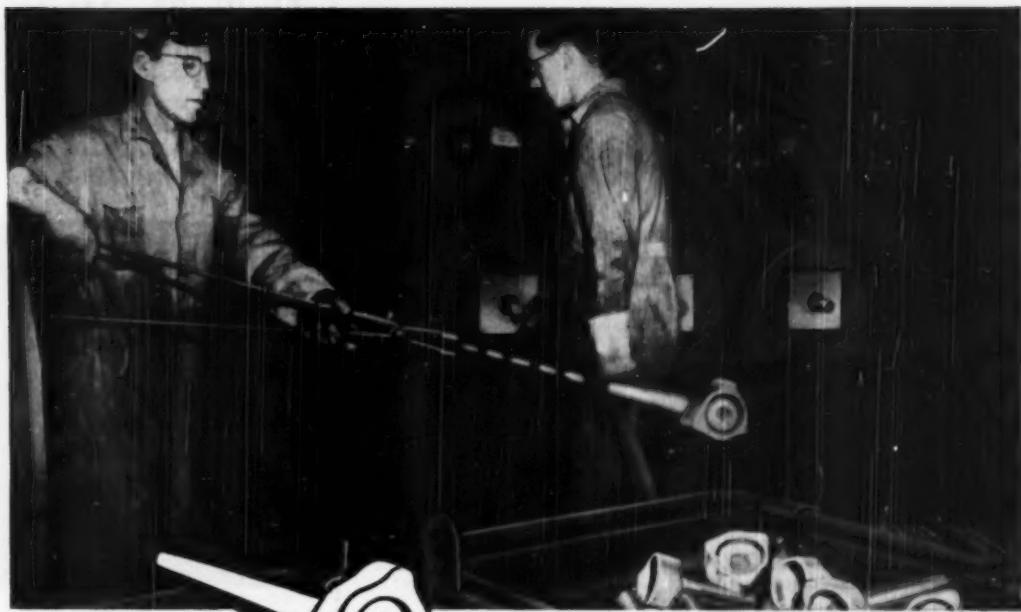
TAM does not make or supply steel of any kind. But, as developers of titanium alloys such as 25% and 40% Low Carbon Ferro Titanium required in making 321, we can furnish much worthwhile data. Write our New York office.



*TAM is a registered trademark.

TITANIUM ALLOY MFG. DIVISION NATIONAL LEAD COMPANY

Executive and Sales Office: 111 BROADWAY, NEW YORK CITY - General Offices, Works, and Research Laboratories: NIAGARA FALLS, N. Y.



193 perfect pieces per hour
with scale-free induction heat

"Steel Saving"

BIGGEST ADVANTAGE OF AJAX-NORTHROP HEAT"

-SAYS LARGE FORGE PLANT

With ordinary furnaces, as much as $3/64"$ of a billet may peel off into scale—scale that wastes tons of steel, wears away dies, pits surfaces. But in up-to-date shops, modern Ajax-Northrup furnaces heat billets so fast there's no time for scale to form. This saves up to 20% of the steel cost for some forgings, with longer die life, closer tolerances and smoother finish. No start-up time; no need to pull stock out of furnaces during shut-downs.

Many types of Ajax-Northrup furnaces are available to heat all or any required portion of a billet with precise temperature gradient and control, and with complete automatic timing and feeding. Trouble-free motor-generator power sources with flexible hook-ups handle a wide variety of jobs with reasonable investment and remarkably low overall forging costs. Call on Ajax-Northrup's 34 years of experience.



Write for copy of Ajax-Northrup Heating Bulletin 13A

AJAX ELECTRO THERMIC CORPORATION
AJAX PARK, TRENTON 5, N. J.

Associate Companies

AJAX ELECTRO METALLURGICAL CORP. • AJAX ELECTRIC COMPANY, INC.
AJAX ELECTRIC FURNACE CORPORATION • AJAX ENGINEERING CORPORATION



125

AJAX
ELECTRO THERMIC

**HEATING
&
MELTING**

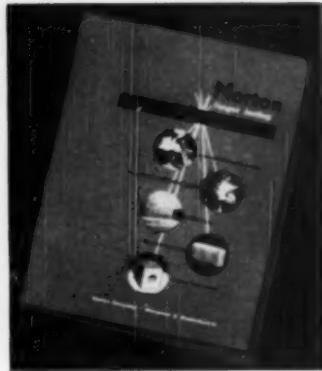
Up-To-The-Minute Facts About Refractory Cements



HIGH FREQUENCY INDUCTION FURNACE lined with Norton RM-1169 Magnorite* cement having a maximum use temperature of 3250°F.

LINED TO LAST AT 3250°F ...with *Norton MAGNORITE Cement*

To get more heats out of your high frequency induction furnace linings, try dry-ramming with Norton RM-1169 Magnorite cement. RM-1169 is a result-proved mixture of very coarse electrically fused magnesia grain and enough ceramic binder to give you a dense pack. Maturing at 2100°F, it takes temperatures up to 3250°F in stride. RM-1169 matures in the first heat at the inner edge only. No all-the-way-through cracks to short out your furnace! Easy and inexpensive to install, it also gives you a lining that's easy to patch. It will pay you to make a test run of Norton RM-1169 Magnorite cement next time one of your furnaces needs relining. Order from your nearby Norton refractory distributor. NORTON COMPANY, WORCESTER 6, MASSACHUSETTS.



*"The most helpful
bulletin on
refractory cements
ever published"*

That's the opinion of the foundry and furnace men who have read this new Norton bulletin. Compiled after exhaustive laboratory and field tests by Norton refractory engineers, this bulletin covers the entire subject of Norton cements with charts, drawings and detailed instructions.

Selection charts

If this bulletin contained nothing but its two selection charts, it would be well worth sending for. At a glance, you know the right cement for various metal-melting furnaces, for brick laying, for resistor imbedding, for burner blocks and tunnels.

"How To" Instructions

Other subjects covered by this booklet include correct preparation, proper installation, drying and maturing . . . all the do's and don'ts that add up to longer-lasting cement applications.

Write for bulletin 863

NORTON COMPANY

321 NEW BOND STREET
WORCESTER 6, MASS.

* Trade-Mark Reg. U. S. Pat. Off.
and Foreign Countries



Making better products to make other products better

Special REFRactories

Canadian Representative
A. F. GREEN FIRE-BRICK CO., LTD. TORONTO, ONTARIO

Copyright, 1950, by American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. Published monthly; subscription \$7.50 a year in U.S. and Canada (foreign, \$10.50); single copies \$1.50. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879. The American Society for Metals is not responsible for statements or opinions printed in this publication. Requests for change in address should include old address of the subscriber; numbers missing due to "change in address" cannot be replaced; claims for undelivered copies must be made within 60 days.

METAL PROGRESS

The Magazine for Metallurgical Engineers

Vol. 58

November, 1950

No. 5

Table of Contents

Conservation of Columbium

Aircraft Industry

L. Rotherham (p. 692), W. E. Cooper (p. 692), J. B. Johnson (p. 693), L. H. McCreery (p. 693), H. Clements (p. 694), R. R. Janssen, L. P. Spalding, F. B. Bolte (p. 694), John W. Sweet (p. 694), K. F. Finlay (p. 695), R. H. Thielemann (p. 695), W. E. Jones (p. 695), E. R. Gaal (p. 701), J. K. Wilson (p. 701), H. E. Gresham (p. 701), H. E. Lardge (p. 701), J. H. Cork (p. 701), R. E. Packer (p. 702), S. T. Harrison (p. 702), Bernard Gross (p. 702), N. E. Promisel (p. 705), K. W. Clarke (p. 768).

Chemical Industry

H. L. Maxwell (p. 696), F. H. Keating (p. 696), R. F. Brown (p. 697), G. F. Lockeman (p. 697), H. H. Brown (p. 698). (See also C. Sykes, p. 698)

Other Fabricators and Users

C. T. Evans, Jr. (p. 691), M. E. Holmberg (p. 692), L. L. Wyman (p. 699), H. S. Blumberg (p. 699), M. A. Scheil (p. 699).

Steel Producers

D. W. Kaufmann (p. 691), C. Sykes (p. 698), D. C. Buck (p. 704), F. K. Bloom (p. 750), H. Allsop (p. 760), J. G. Althouse (p. 766), Donald A. Oliver (p. 771).

Foundrymen

E. A. Schofer (p. 708), Charles K. Donoho (p. 708), N. A. Matthews (p. 708), R. J. Wilcox (p. 708), J. F. B. Jackson (p. 708), Edwin Gregory (p. 744).

Tube Makers

D. H. Wiese and H. W. Cooper (p. 703), Harry K. Ihrig (p. 703), C. L. Clark (p. 704), J. A. Deitrich (p. 752), J. S. Adelson (p. 754), J. W. Jenkin (p. 756).

Other Metallurgists

R. David Thomas, Jr. (p. 700), Russell Franks (p. 701), E. C. Wright (p. 742).

Summarizing Statements, by John F. Tyrrell (p. 780)

Technical Articles

Metallography of Zirconium, by H. P. Roth

709

A New Anodic-Film Method for Studying Orientation in Aluminum, by André Hone and E. C. Pearson

713

Casting and Forging of Titanium, by J. Bartlett Sutton, Edwin A. Gee and William B. DeLong

716

Iron Smelting Problems, by Earle C. Smith 721

Phase Contrast Metallography, by R. L. Seidenberg and J. R. Benford 725

Nodular Iron in Theory and Practice, by Metal Progress's Special Representative 729

Critical Points, by the Editor

White Man's Medicine for Red Man 712

Correspondence

Cathodic Vacuum Etching, by Józef Mazur 732

Transfer of Replica From Metal to Electron Microscope, by Harold C. O'Brien, Jr. 732

Galvanic Macro-Etch for High-Purity Aluminum, by L. S. Servi 732

Hallowe'en, by H. O. Walp 733

Thermal Polishing and Etching, by A. G. Metcalfe and M. J. Olney 733

Circular Graphite in Cast Iron, by H. Morrogh 734

Star Fish or Compass-Rose?, by W. Stern 735

Quick Estimation of Case Depth, by Marie H. Whitehill 735

Electrolytic Polishing of Nickel, by Glen W. Wensch 735

Permanent Record of Magnaflux Indications, by Harold H. Lurie 736

Departments

Data Sheet: Hardness Conversions for Titanium and the Relation Between Hardness and Tensile Strength, by J. B. Sutton, E. A. Gee and W. B. DeLong 720-B

Personals 737, 738, 740

Engineering Digest of New Products 667, 668, 669, 670, 672

Manufacturers' Literature 672-A, 672-B

Advertisers' Index 784

COUNSEL AT YOUR PLANT

QUALITY CONTROL AT THE MILL

- Greater enamel bond through special surface preparation.
- Extreme flatness—sheets are made flat and stay flat during enameling operations.
- Excellent sag resistance.
- Correct temper assured by frequent testing of hardness and ductility.
- Unsurpassed drawing and forming qualities.
- Good weldability assured by uniformity of composition and gage.

Extra Deep Draws? Get them with a minimum of breakage by specifying Inland Enameling Iron—specially processed to fit your exact requirements.

TI-NAMEL: A superior base metal that covers *white* with a single cover coat—no ground coat needed. Learn how this titanium alloy steel can help cut your processing and shipping costs. Write for complete information.

way protection

WHEN YOU USE INLAND ENAMELING IRON

You're *twice* as sure of quality when you deal with Inland! First, Inland engineers are always available to study your enameling iron needs in your plant—under the everyday conditions of production. Second, you *get* what you specify—for at Inland each lift of sheets is rigorously tested. Lifts that fall below your requirements are immediately rejected—*sure* quality protection for you.



INLAND STEEL COMPANY, Dept MP-110 38 S. Dearborn St., Chicago 3, Ill.

Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul

OTHER PRODUCTS: BARS • STRUCTURALS • PLATES • SHEETS • STRIP • TIN PLATE • FLOOR PLATE • PILING • RAILS • TRACK ACCESSORIES

In an article, "Conservation of Columbium", in Metal Progress for July, John F. Tyrrell urged the rather general substitution of titanium-stabilized steel (Type 321) for the columbium-stabilized grade (Type 347). Here are the reactions of 56 British and American metallurgists from all industries concerned. Besides comment on Mr. Tyrrell's main thesis, the discussion includes other closely related matters not dealt with in the original article — for instance, the use of stabilized steels in the chemical industries.

Conservation of Columbium

A Summary of British and American Experience With Stabilized Stainless Steels

"When in Doubt . . ."

JEANNETTE, PA.

We believe that Mr. Tyrrell has done the country a real service by bringing the long-standing controversy between Types 321 and 347 out in the open. We have largely been guilty of the policy: "When in doubt, specify 18-8 columbium". Mr. Tyrrell makes it obvious that at least where sheet products are concerned, we should not be in doubt about the over-all serviceability of 18-8 titanium.

The big problems with the titanium-bearing steels have been cleanliness and quality. Solar's experience demonstrates that these problems have been solved for sheet products, at least by some suppliers.

C. T. EVANS, JR.
Chief Metallurgist
Elliott Co.

Supply Situation

PITTSBURGH

Mr. Tyrrell's article is not only of considerable interest to users and makers of stainless steel, but also is unusually timely. We who manufacture stainless and heat resisting alloys have long been concerned

about alloy conservation, which is so vital to our national security. In the few short years since World War II, the consumption of steels containing large quantities of chromium, nickel, tungsten, cobalt and columbium has increased tremendously. This puts a strain on the facilities which produce such raw materials to the extent that they cannot always meet the demands imposed on them. The result is a shortage of high-alloy steels, even though the actual steelmaking capacity is adequate. However, this is not nearly so serious a condition as allowing ourselves to become dependent on metals or ferro-alloys which might suddenly become practically unavailable in an emergency.

In his article, Mr. Tyrrell has contributed knowledge gained over a period of years in the production of "more than 400,000 exhaust manifold sets for aircraft engines". The data obtained from such extensive experience certainly should command the attention of all production-minded engineers. Too often our decisions as to the use of high-alloy materials must be based on the results of isolated laboratory tests which do not always duplicate anticipated service conditions. In this

BULLETIN

WASHINGTON, Oct. 19 — The entire production and use of columbium-bearing stainless steels will be reserved for defense needs under an order issued today by the National Production Authority. The order, NPA Order M-3, prohibits the use of ferrocolumbium-bearing steels or ferrotantalum-columbium-bearing steels where any other substitutes can be used.

instance, we are assured that, using proper production techniques, Type 321 steel can be formed, welded and used without difficulty.

The important question to be answered in considering steel applications is not, "How much better is Type A than Type B?" but rather, "Which steel will provide the required properties at minimum cost per fabricated unit?"

From the standpoint of the steelmaker, our chief interest lies in our ability to supply the needed materials. With respect to the stainless steels under discussion, manufacture presents no unusual problems, and

we are limited within present capacities only by the availability of the alloying elements involved.

D. W. KAUFMANN
Metallurgist
Crucible Steel Co. of America

British Aircraft

FARNBOROUGH, ENGLAND

Broadly speaking, our experience in this country confirms Mr. Tyrrell's recommendations and suggests that further efforts toward columbium conservation would be worthwhile. The use of columbium for aircraft purposes falls into two categories: (a) high-temperature materials of the so-called superalloy type, and (b) general-purpose austenitic steels of the 18-8 type.

Considering high-temperature materials first, the best turbine blading alloys and some of the best disk alloys in the U. S. have been columbium-bearing, whereas in the U. K. columbium has never found much application in blading material but has been used extensively in disks. Our practice has been due to the experience that the columbium-bearing alloys have remarkable casting and forging properties so that large masses can be produced with great reliability. The titanium-bearing alloys can be produced best in small masses suitable for blading. At every stage of engine and alloy development there has been a titanium-bearing material with properties equivalent to the columbium-bearing alloy, but these have not been used in large forgings because of production difficulties. Production rates might well be a dominant factor in wartime and would suggest that an addition to the present extensive research into production methods would be desirable. Even so, although the production and use of titanium-bearing alloys might be extended, it will be a long time before they are made as readily as current columbium-bearing alloys.

Turning to the 18-8 type of material, the same considerations apply but to a lesser extent. Generally, better and cleaner ingots are more readily produced with columbium than with titanium, but no real difficulty is found with the latter. Production of 18-8Ti in this country has always been much more extensive than production of 18-8Cb — to such an extent that 18-8Ti can properly be regarded as the standard welding quality of 18-8. Large

quantities of this material have been used successfully for components such as engine exhaust manifolds or the sheet metal parts of turbines. The advantages of using 18-8Cb in aircraft appear to be in the production of intricate castings and in having a more pleasing appearance in the surface of highly polished sheet. These seem slight advantages to offset against the objections which can be raised to its uses.

The situation has now been reached when columbium is being recognized for what it is — a relatively rare metal. It is likely to become progressively less readily available, and even if available its price must almost certainly increase substantially. Economic factors will therefore operate tending to increase efforts to devise effective substitutes, but some of these will require extensive research and may take considerable time. In the meantime, as Mr. Tyrrell shows, an effective substitute is already available in certain fields of application, while in others columbium has distinct advantages and no replacement is possible. It would be a praiseworthy act of self-discipline if manufacturers could reach agreement in limiting the use of columbium to essential applications, and at the same time initiate the research, possibly on a cooperative basis, necessary for extending the use of substitute materials.

L. ROTHERHAM
Head of Metallurgical Division
Royal Aircraft Establishment

HAYES, ENGLAND

This country has many years' successful experience of the reliability of titanium-stabilized steels to support Mr. Tyrrell's recommendation. Application of austenitic stainless steel in British aircraft is usually restricted to (a) parts requiring heat resistance, including strength at elevated temperatures, (b) where cadmium-plated ordinary steel is unsuitable, and (c) where nonmagnetic properties are essential. For upwards of 20 years, all austenitic stainless steels used in the British aircraft industry (18-8 and the later 23-14 and 23-18 heat resisting types) have been stabilized, to pass the weld decay test. It is probably safe to say that well over 90% of these steels have been stabilized with titanium.

In the main, it is difficult to discriminate between titanium-stabilized steels and columbium-stabilized

steels for ordinary purposes but, on account of the increased cost of the required columbium addition, the use of columbium (which has shown no apparent advantages) has not found favor for the general constructional varieties.

In certain instances, however, we have found that columbium has advantages: It is standard practice to use columbium in place of titanium in electrodes. It is also found that columbium-treated steel can be given a much more highly polished finish than a corresponding titanium-treated steel, which may contain titanium inclusions. However, the tonnage of columbium-treated material is small.

With regard to the comparison of the properties of titanium and columbium-stabilized steels for high-temperature purposes, as for turbine blades in jet engines, while individual investigators appear to have noted differences in the high-temperature properties (for example, creep), it is not altogether certain that the differences found are attributable to the type of stabilizing element, as the basic composition and structure of the material can be much more influential. Therefore, it is the general opinion that any differences between columbium and titanium steels are only slight.

W. E. COOPER
Chief Metallurgist
Fairey Aviation Co., Ltd.

EDITOR'S NOTE: The writer of the above letter, Mr. W. E. Cooper, has been chairman of the Materials Committee of the British aircraft industry for more than eight years. During the last war, he was actively concerned with the U. S. and British Commonwealth Aircraft Interchangeability Schedule, which was subsequently published as S.A.E. Aeronautical Information Note No. 8.

Is Stabilization Necessary?

BARTLESVILLE, OKLA.

The oil industry uses large tonnages of 18-8 and other austenitic steels in gas cracking and in still tubes. Many of these installations are of welded construction. Metal temperatures are generally in the carbide precipitation range during operation. Therefore, it was originally believed necessary to use stabilized grades.

Operating experience showed that the inside of the tubes became carburized in service. Because of the increase in carbon content, there was not sufficient columbium or

titanium present to keep the metal stabilized. If the tubes do not remain stabilized in service, why use stabilized steel in the first place? Most installations are now made with ordinary 18-8 and other unstabilized austenitic steels, and the performance has been entirely satisfactory. There are other applications of welded austenitic steels that do not require the stabilized grades even though they operate in the carbide precipitation range. Is it possible that the aircraft exhaust manifold is such an application?

M. E. HOLMBERG
Phillips Petroleum Co.

American Aircraft

DAYTON, OHIO

The exhaust equipment for aircraft engines was first manufactured from low-carbon steel, but corrosion and low mechanical strength at operating temperatures led to the introduction of 18-8 stainless steels. The unstabilized stainless proved unsatisfactory due to a combination of operating stresses and corrosion in those portions of the manifolds which were subjected to high flame temperatures. (The accompanying illustration shows a characteristic service failure that occurred near a welded seam in an exhaust manifold made of unstabilized material; the micrographs indicate the type and extent of corrosion on specimens taken adjacent to the crack.) It was also very difficult to clean the equipment on overhaul, except by pick-



Fig. 2 — Failure in Corroded Turbosupercharger Nozzle Boxes
From a B-24 Airplane. Steel is unstabilized Type 316

ling, which causes embrittlement of the unstabilized material.

The use of stabilized stainless steel since the early 1930's has practically eliminated all failures, except those due to design and faulty installation. More recently, after an epidemic of failures, it has been found necessary to change to a stabilized material in superchargers, due to the rapid corrosion and embrittlement of unstabilized Type 316.

The problem of selecting the correct steel for application at elevated temperatures is never simple, because the operating conditions are often not completely known or controllable. The selection is normally made on the basis of engineering properties, previous experience, and economics. The engineer is reluctant to change a material that has given satisfactory service. Failures during operation sometimes compel it.

In general, the service life and the character and frequency of repairs on aircraft components are influenced to a much greater extent by design and installation than by small differences in the properties

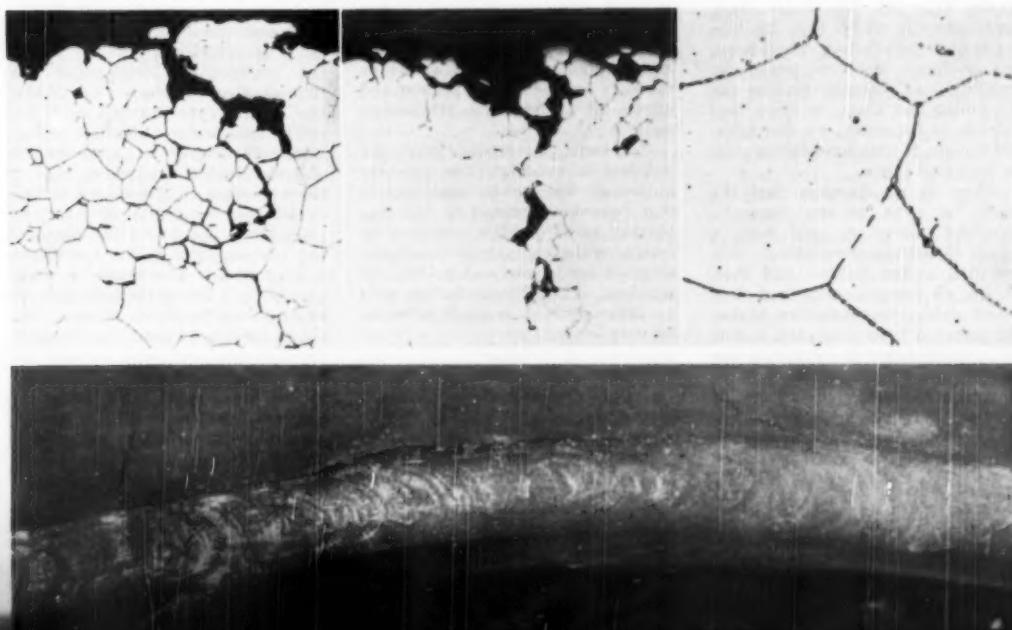
of the materials. Several years of operating experience with equipment fabricated from both grades of stabilized stainless steel have not indicated any preference or advantage for either Type 321 or 347. However, columbium has always been an element available only in limited amounts, due to the scarcity of the known ore supplies, and it is therefore essential that columbium be conserved. A practical approach to conservation is to encourage the use of Type 321 steel for the components referred to by Mr. Tyrrell.

J. B. JOHNSON
Chief, Metallurgy Group
Office of Air Research

ST. LOUIS

The use of both Types 321 and 347 stainless steels in aircraft components has been a practice of long standing. There seems never to have been a logical reason for using 347 in these applications except for the fact that at certain times it was more readily available than 321. This, no doubt, can be accounted for by the fact that 347 is more

Fig. 1 — Service Failure Near Weld in Exhaust Manifold Made From Unstabilized Stainless Steel



widely used in the chemical industry, particularly to resist nitric acid. Since there was little or no difference between 321 and 347, with respect to mechanical properties, the use of 347 was attempted. In most parts, Type 347 was suitable except in some isolated instances where deep draws were required. For these reasons, 347 was accepted as an alternate for 321, even though it was generally somewhat more expensive. Our experience with using the two materials indicates that either is equally suited to use in aircraft components. Primarily because the need has not arisen heretofore, no attempt has been made to standardize on either type of stabilized steel.

In order to assist in conserving columbium, this company now proposes to specify Type 321 titanium-stabilized 18-8 stainless steel on all new designs which require corrosion resistance and heat resistance and also to analyze its present usage of Type 347 columbium-stabilized 18-8 with the purpose in mind of replacing all 347 with 321. A recent preliminary survey of this problem indicates that 347 can be replaced with 321, thereby conserving considerable quantities of columbium, nickel and manganese.

L. H. McCREEY
Metallurgist
McDonnell Aircraft Corp.

WOOD-RIDGE, N. J.

We have used both columbium-stabilized and titanium-stabilized steels, but have specified Type 347 for some parts made from tubing, not because of stabilization, but because of seams caused by titanium in the Type 321. There are many applications in which Type 321 tubing is quite satisfactory when properly produced. However, one of our suppliers had difficulty making the 321 tubing and since we knew that it tends to be seamy, we discontinued the use of titanium-bearing steel on thin-wall parts.

There is no question that the seams in some of the titanium-stabilized tubing we used were a source of mechanical weakness. We first had engine failures and then set up an inspection method that would detect the defective tubing and permit it to be separated. Later, we concluded that discontinuing the use of Type 321 tubing was a safer procedure for the aircraft parts in question.

Our application was fuel-injection lines operating at low temperature

and the only reason for stabilizing was to prevent carbide precipitation during brazing. After first changing to the columbium type, we subsequently adopted unstabilized 18-8 of low carbon content, because the producers stated that manufacturing procedures were simplified when no columbium was used.

B. CLEMENTS
Metallurgical Engineer
Wright Aeronautical Corp.

LOS ANGELES

Although there may be differences of opinion concerning the proper stabilizing agent for 18-8, there can be no argument about the columbium supply situation — there is a serious shortage in supply.

Among the aircraft applications of stabilized 18-8 mentioned in Mr. Tyrrell's article, one of the most demanding has been exhaust collectors, which generally operate with high pulsating stress at about 1200° F. For such components, even small differences in design are sufficient to mask any effect from differences in material that might otherwise be noticeable. North American Aviation, Inc., has had no opportunity to compare service performance of 321 with 347 in *identical* design. Our experience with designs that are similar but not identical indicates no significant difference in service performance between 321 and 347. Because 347 uses the more strategic columbium and is more costly than 321, we prefer 321. Problems of ready availability have often dictated the use of 347 interchangeably with 321.

We have found no real difference in the forming properties of 321 and 347 which could be attributed to the stabilizing element, and we feel that any difference which might exist is masked by the more pronounced effects of tooling and fabrication method.

Similarly, neither alloy poses any problem in welding. The only requirement we consider necessary is that columbium should be the stabilizing agent in filler rod used in fusion welding. If an inert-gas-shielded arc is used and no filler is required, as in a "flange burndown", no differentiation is made between the two steels.

R. R. JANSSEN
Material and Process Engineer
L. P. SPALDING
Director of Research
F. B. BOLTE
Assistant Chief Research Engineer
North American Aviation, Inc.

SEATTLE, WASH.

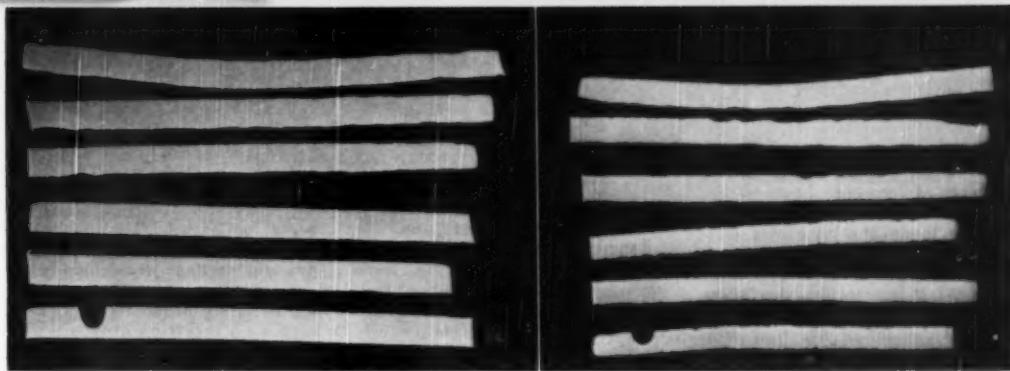
It has been our experience that Types 321 and 347 can be used interchangeably for aircraft applications and we so specify on our drawings. We actually purchase considerably more 321 than 347 because of its lower price and generally increased availability.

Types 321 and 347 were used interchangeably on the B-17 and B-29 airplanes. They were used in all applications where stainless steel was assembled by welding. The welding was done with columbium-stabilized rod and no difficulty was experienced with Type 321.

Other applications for these steels were where the temperature was to be in excess of 800° F. This included the exhaust system and shrouding of some areas of the exhaust system. Service experience has shown 321 to be satisfactory when operating below 1500° F.

The reciprocating engines now being used on larger aircraft are developing exhaust gas temperatures in the vicinity of 1850° F., and the exhaust stack material must give a satisfactory operating life. The effect of temperature on the properties of various heat resistant materials when tested in air at service temperatures is available, but this is not the controlling factor. The corrosion plus high-temperature oxidation and erosion effect of the service environment are the predominating factors.

We have used a cyclic test to evaluate several materials for actual service tests. This laboratory test was developed by the General Electric Co. to simulate service conditions (see *Iron Age*, March 6, 1947). The test attempts to follow the cycle of actual operation in which the products of combustion are deposited on the stack wall. When the engines are stopped and the stacks cool, water condenses on the walls. The engines are again started and the stack temperatures rise to the operating temperature. In the cyclic test a sample of metal is placed in a 250-ml. beaker containing 150 ml. of distilled water and 5 g. of $PbBr_3$. The beaker is then placed on a hot plate and allowed to evaporate slowly to dryness and baked for 5 to 10 min. The temperature of the solution is maintained between 140 and 160° F. and 12 to 16 hr. are required for complete evaporation. The solution is stirred approximately every 2 hr. After baking, the dry piece is placed in



Titanium-Stabilized Steel (Type 321)

Columbium-Stabilized Steel (Type 347)

Specimens Tested for Susceptibility to Lead Bromide Attack at High Temperature (John W. Sweet)

a shallow quartz boat and heated 1 hr. in a furnace at an elevated temperature representative of service temperature and allowed to cool in air; then distilled water is added and the complete cycle is repeated twice. The accompanying illustrations show representative cross sections of 321 and 347 tested in this manner. The three specimens on the lower half of each macrograph were cycled to 1200° F. and the three on the upper half were cycled to 1500° F. This indicates superiority of Type 321 when subject to lead bromide attack under the test conditions.

It is our opinion that service tests or simulated service tests are the only satisfactory means of comparing different alloy compositions and of assuring satisfactory service from materials used for exhaust stacks of reciprocating engines used on the larger aircraft. The high temperatures, in conjunction with stresses, leaded fuel and other operating factors, result in conditions that cannot be duplicated in standard test procedures.

JOHN W. SWEET
Chief Metallurgist
Boeing Airplane Co.

HAWTHORNE, CALIF.

Mr. Tyrrell's remark that the columbium in Type 347 *prevents* carbide precipitation during exposure in the sensitizing range of temperatures is in my opinion subject to review. "Substantially reduces" might be a better expression.

In my opinion his demonstration of the superior formability of 321 over 347 is corollary with the increased hardening effect of columbium compared to titanium, and also the slight advantage of 347 over 321 in terms of creep strength above 1000° F. This latter point is more academic than significant to aircraft design. Northrop Aircraft, Inc., has

established equivalence for most applications, especially in the moderate temperatures below 800° F.

The welding technique is believed to be more critical with 321 than 347 because of the questionable replacement, completely, of titanium-starved areas. For that reason extreme care is exercised by us in the use of columbium-rich metallic arc rod for welding 321.

K. F. FINLAY
Metallurgist
Process Engineering Dept.
Northrop Aircraft, Inc.

EAST HARTFORD, CONN.

Our use of the two grades of stabilized stainless steel has been for jet engine components and has been quite limited, since the majority of the sheet metal parts require the maximum resistance to oxidation and corrosion that is attainable. For this reason, 25-20 Cr-Ni steel or alloys of the Inconel type are finding wider application.

Except for special purposes or to facilitate certain processing procedures, it is my opinion that Types 347 and 321 are equivalent and that for the majority of applications either grade can be successfully employed. There are a few instances where we feel the somewhat higher creep strength obtainable with 347 is an advantage. Also, we have found that 347 is superior where silver or copper brazing is specified, since 347 is more easily wetted and gives off less gas at the brazing temperatures than does 321. Where resistance welding is specified, the titanium grade seems to offer an advantage. For fusion welding, either grade is satisfactory, but the columbium-stabilized welding rod is specified.

In my opinion, the strongest argument for 347 over 321 is that it is more uniform; also, it is usually cleaner. Once the melting problem

is overcome, the biggest handicap associated with the 321 grade, in my opinion, will have been solved.

R. H. THIELEMANN
Development Metallurgist
Pratt & Whitney Aircraft

WEST LYNN, MASS.

General Electric's experience has been primarily with Type 347 stainless steel. This was originally chosen because of slightly higher creep and rupture strength, superior welding characteristics using the atomic hydrogen process (which was in wide use at that time), and lower susceptibility to intergranular corrosion in the Strauss test. With the shortage of ferrocolumbium, considerable effort has been made to replace the columbium-stabilized steel with the titanium grade (Type 321) and with appreciable success.

The chief disadvantage with Type 321 is the difficulty it presents in welding with the atomic hydrogen process. In the last few years, there has been a shift from the atomic hydrogen process to the inert-gas-shielded arc process; however, there still remain numerous applications for the atomic hydrogen process. The trouble lies in the formation of a scum which makes atomic hydrogen welding slow, difficult, and of poor appearance.

Also, 321 has been difficult to produce with a surface quality comparable to 347. This is of considerable importance in some parts that are subject to fatigue stresses.

Welding experience with the inert arc, metal arc and resistance techniques substantiates the work done by Mr. Tyrrell. Type 321 offers a definite advantage over 347 in the inert-gas-shielded arc process, as it is apparently not so subject to weld cracking when the joint is made at high speeds.

No difference has been observed

between 321 and 347 in the various methods of forming. Shop procedures have not been changed other than to lower the annealing temperature to 1800° F. for 321.

With regard to stabilization of Type 321, it appears that the industry-wide standard, requiring a titanium content of five times the carbon content, is too low, and that a minimum of six times carbon is desirable. This fact has been noted in laboratory examination of various heats and is substantiated in publications by S. J. Rosenberg of the Bureau of Standards. (See, for instance, "Stabilization of Austenitic Stainless Steel", *Transactions, American Society for Metals*, Vol. 41, 1949, p. 1261.)

Another possible solution to the program to conserve columbium is the use of somewhat more available ferrotantalum-columbium to stabilize the austenitic stainless steel. Tests are in progress on several heats with varying ratios of columbium plus tantalum to carbon. There seems to be very little difference between the corrosion characteristics of these alloys and the regular Type 347. The ratio of columbium plus tantalum to carbon has to be about 11 minimum for complete immunity to intergranular attack.

The mechanical properties of the alloys containing both tantalum and columbium are comparable with Type 347, with the possibility of slightly higher stress-rupture strength at 1200° F. In some instances, the rupture ductility has been lower than anticipated or desired. However, with the accumulation of data it appears that the range of rupture ductility will be about the same as for Type 347.

In laboratory welding tests (atomic hydrogen, metal arc, inert arc, resistance), the 347 Ta-Cb alloys weld in a manner comparable with the regular 347.

With the present critical shortage of ferrocolumbium, it is apparent that the available supply will be diverted to the high-temperature alloys which require the columbium to gain their high strength. This means that the users of 347 steel will have to choose an alternate in either 347 Ta-Cb or 321. All things being considered, it appears that the better choice in the long run is Type 321.

W. E. JONES
Thomson Laboratory
General Electric Co.

Stabilized Stainless in the Chemical Industries

WILMINGTON, DEL.

Mr. Tyrrell's informative article serves well in pointing up some pertinent factors in the current outlook for the economy of columbium. The rigid allocation of this strategic alloying additive during World War II forced economies and general substitutions in plant equipment construction which in many cases were abandoned as soon as the emergency was past.

Agreement, in general, can be found with much of the physical data and process information presented in this comparison of materials for aircraft services in which high operating temperatures are encountered. The replacement of columbium by the more readily available titanium stabilizing agent in stainless alloys for severe chemical plant service is not so clearly defined from practical considerations as was reported in this study of aircraft applications.

When it comes specifically to selecting a stabilizing agent for stainless steel in extremely corrosive service, there has been and still is a difference of opinion as to the reliability of titanium versus columbium. We have had good performance from both materials in some services. However, in the most critical applications, particularly those processes using hot nitric acid — one was of the greatest strategic importance — the judicious use of columbium in a properly balanced alloy shows an advantage over titanium as a stabilizer.

By way of individual experience, we have been making impartial reappraisals of old and new specifications and recommendations. In more than a few cases, we are building plant extensions from Type ELC 304 and conventional Type 304 where there is reasonable indication that the stabilized grade used in the semiworks or in some of the initial plants was not actually necessary. Equipment design limitations and also conditions for fabrication in the field must not be lost sight of in any calculated substitutions of Type 304 for either 321 or 347.

The use of stabilized austenitic castings warrants a brief reference. The frequently observed greater loss of titanium over columbium during melting has long been ac-

cepted as factual. The fabrication of weldments in which castings and wrought sections are joined without subsequent heat treatment for use in severe nitric acid corrosion presents a recurring problem, with the present solution to it calling for stainless steel castings stabilized with columbium.

It is at once recognized that there are hundreds or even thousands of plant corrosive service conditions ranging from the mildest noncorrosive service to the most severe where equipment life is recorded in weeks or even days. All along this graduated scale of increasingly severe service conditions competent opinion will likely vary. Each one may be satisfied for a time with his own answer. Current discussion of the conservation of columbium will have served a useful purpose if it stimulates a revival of thinking and experimentation on this subject and thereby encourages engineers responsible for the selection of materials to make impartial and rigid reappraisal of their needs.

H. L. MAXWELL
Supervisor of General Consultants
Engineering Dept.
E. I. du Pont de Nemours & Co.

Nitric Acid Service in Britain

BILLINGHAM, ENGLAND

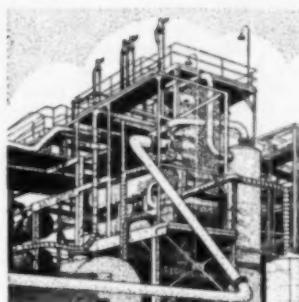
I have read with very great interest the article by Mr. John F. Tyrrell in the July issue of *Metal Progress*. The facts and experience which Mr. Tyrrell recounts are in a different field of activity from those dealt with in my article of December 1948,* and are therefore directly additive to the weight of evidence already produced for reconsideration of the position of columbium as a stabilizing element.

*EDITOR'S NOTE: The article referred to, "The Austenitic Stainless Steels — American and British Practice Compared" (*Metal Progress* for December 1948), includes a column of discussion under the heading *Titanium or Columbium for Stabilization?* which concludes with this prophetic sentence: "It may be well to ask whether the long-term view would not be to encourage the use of the element [titanium] that has given good performance over a period of years and that is in abundant supply in the earth's crust, rather than a material [columbium] that may become scarce."

In one part of his article, Mr. Tyrrell does deal with the chemical industries and makes a statement which would indicate that Type 321 stainless steel has poor resistance to nitric acid. The statement is a general one, and would give the impression that Type 321 should not be considered for nitric acid plant construction. In the writer's experience, this statement is entirely misleading and is probably another product of the widespread misuse of the boiling nitric acid test [Huey test] as a general assessment test. It is a fact that many nitric acid plants in this country are constructed entirely of Type 321 steel and have given complete satisfaction for many years. The only single application on straight nitric acid duty in which the writer has found Type 347 steel to be superior to Type 321 is in the storage of acid of 95% concentration. Even in this use, the Type 321 steel fails not by general corrosion but by channeling attack on a narrow zone immediately adjacent to the weld. Type 347 steel is entirely immune to this type of attack. Initial studies indicate, however, that it is not impossible that a solution to the problem of attack on the titanium-stabilized steel may be found other than the substitution of columbium-stabilized steel. It can be shown that the attack results from the structural rearrangement resulting from heating the steel in a narrow range close to the fusion range. It is possible that the troublesome structure in the susceptible narrow zone can be controlled by diffusion from a carefully selected electrode composition. Even if no specific solution is forthcoming, however, it is important to note that a few isolated cases of this kind do not give a logical basis for rejecting Type 321 steel entirely for nitric acid duty.

Apart from the economics of the situation, which Mr. Tyrrell mentions, it would appear that scarcity exaggerated by demands for military equipment may force a reassessment of the uses of columbium in all industries. So far as the chemical industries are concerned, the writer is convinced that a considerable portion of its requirements can satisfactorily be met by the use of titanium-stabilized steel.

F. H. KEATING
Chief Metallurgist
Billingham Division
Imperial Chemical Industries, Ltd.



Nitric Acid Service in Kansas

PITTSBURGH, KAN.

Mr. Tyrrell's article on the use of Type 321 stainless steel is most certainly of interest, coming as it has at a time when columbium is in such great demand and short supply. The fact that Solar Aircraft Co. has for some time been using 321 by choice when 347 was available, is a significant point that should not be overlooked by the various fabricators in this country who have been automatically specifying 347 on the assumption that it is superior.

A reference is made in Mr. Tyrrell's article to the effect that Type 321 steel is not satisfactory from the standpoint of chemical corrosion — particularly in nitric acid. I believe that this statement is incorrect or, at any rate, misleading. Spencer Chemical Co. owns and operates a large nitric acid plant producing more than 400 tons per day of 100% equivalent, 55% nitric acid and many of the materials of construction in contact with the acid are fabricated from Type 321 steel. In this category can be named nitric acid heaters, condensers, oxidizers, storage tanks, absorption drums and cooling coils. The only weak point where corrosion has been evident in the system has been around one particular tube sheet where hot gases at approximately 700° F. come in contact with condenser tubes. Replacement tubes fabricated from 347 steel showed absolutely no improvement over 321. However, when these tubes were replaced with low-carbon Type 304 (0.03% max.), they operated a great deal more satisfactorily than when 321 or 347 was used.

R. F. BROWN
Chief Engineer
Spencer Chemical Co.

Soap Chemicals

CINCINNATI, OHIO

A considerable amount of Type 347 has been used for handling fatty acids and some inorganic acids because of slightly better corrosion rates than with Type 321 and a minimum loss of columbium due to welding. However, our plant corrosion tests in fatty acids (both liquid and vapor) show satisfactory rates for both 321 and 347.* Specimens of 321 were welded with both 321 and 347, and tests were made with sensitized and unsensitized specimens. Corrosion rates were slightly higher for 321 but were well within satisfactory limits for service conditions.

General corrosion and pitting are usually important considerations in chemical process equipment made from a stabilized steel, and we have found these more sensitive to the fabricating processes and heat treatment than to the type of stabilizer.

There seems to be a similar situation in "Type 318" alloy† [0.08% C max., 17 to 19% Cr, 13 to 15% Ni, 2 to 3% Mo, stabilized with 0.50 to 1.00% Cb] and the Firth-Vickers FMB-3T or Brown Bayley BB-4K, which are molybdenum-containing steels stabilized with titanium. Satisfactory rates have been obtained with the latter two steels in service tests with fatty acids and mixtures of inorganic acids and fatty alcohols. However, in nitric acid tests of both sensitized and unsensitized specimens, Type 318 has a lower loss than the titanium-stabilized steels with molybdenum. Strauss tests were satisfactory with both.

As with Types 321 and 347, corrosion rates of Type 318 and the molybdenum-titanium stabilized alloys seem to be more sensitive to fabrication methods than to titanium or columbium as stabilizers.

G. F. LOCKEMAN
Engineering Division
The Procter & Gamble Co.

* EDITOR'S NOTE: Similar plant corrosion tests have been reported by George F. Comstock (A.S.T.M. Special Publication No. 93, 1950, p. 200). Based on weight loss measurements, his results may be summarized as follows: No difference between 321 and 347 (all specimens completely resistant) in alum, fatty acids and 40% nitric acid solutions. Type 347 slightly better than 321 in 99% sulphuric acid and in fatty acids and fatty acid derivatives such as nitriles and amines. Type 321 slightly better than 347 in acid inorganic sulphates and in sulphite plus sulphur dioxide.

† Not a standard A.I.S.I. type.

Prevention of Carbide Precipitation

ROCHESTER, N. Y.

Although we use considerable quantities of stainless steel in contact with corrosive chemical solutions, most of these applications are satisfactorily filled by Type 304 or 316. We use very little stabilized material. Most of our chemical equipment is constructed from light-gage sheet (up to and including $\frac{1}{8}$ in.), and deleterious carbide precipitation is prevented by water cooling the steel during welding.

H. H. BROWN
Metallurgical Laboratory
Eastman Kodak Co.

More Chemical Application

SHEFFIELD, ENGLAND

Mr. Tyrrell's article states very fairly the case for the titanium-stabilized steels, such as A.I.S.I. Type 321, and most British metallurgists would agree generally with the findings. However, the reference to the "relatively low resistance to corrosion [of Type 321] in specific chemical mediums such as

nitric acid" is apt to give an unduly pessimistic impression. Nitric acid is the main medium where trouble may be encountered, but neither Type 321 nor Type 347 is suitable for continuous service in boiling concentrated nitric acid. The accompanying photograph shows a portion of a nitric acid plant made in 1931 from titanium-stabilized 18-8 ("Staybrite F.D.P."). So far as I am aware, it is still functioning. The particular illustration is of the oxidizer cooler, but considerable quantities of the steel were also used for other items of plant such as concentrating columns and storage tanks.

As steelmakers, we cannot go into detail regarding the chemical processes for which the steel in question is being used here. However, a few applications may be referred to in which the titanium-stabilized steel (our F.D.P. grade) has proved satisfactory over a long period of years.

Preparation and Storage of Fine Chemicals — One large firm in this country installed various types of chemical plant and storage vessels (for fine chemicals and pharmaceutical products) involving many

tons of F.D.P. in their new factory in 1933. This plant is still giving very satisfactory service. While the majority of the plant is in F.D.P. steel, it was necessary of course for some applications to use the molybdenum-bearing F.M.B. steel. (Standard F.M.B. is not stabilized; there is a smaller demand for a type of F.M.B. with about 0.3% Ti.)

Textile Processing and Dyeing

— A very large tonnage of F.D.P. steel has gone into the textile industry. Among other applications may be mentioned wool scouring plant, calender rolls and dyeing machines. Again, although F.D.P. has hitherto been the standard material for dyeing plant, there is now a gradual change-over to the molybdenum-bearing F.M.B. type where higher intrinsic corrosion resistance is required.

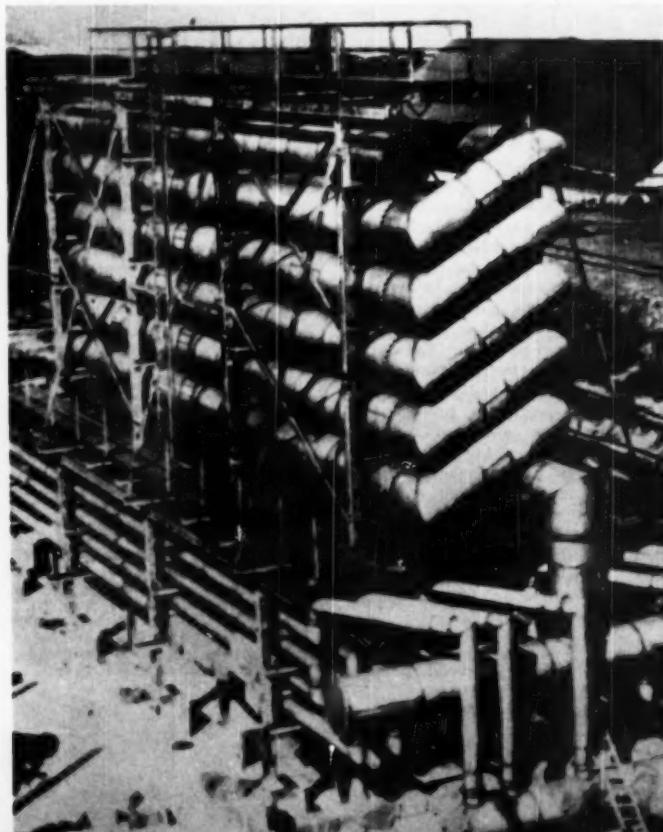
Dyestuffs — Apart from the process of dyeing, considerable quantities of F.D.P. are used in plant for the preparation of the dyes.

Foodstuffs — The dairy industry in particular makes extensive use of F.D.P. for many purposes such as plant for the production of evaporated milk and milk powder. It is also used for the more general applications such as rail and road transport tanks, pasteurizers, separators, coolers, cheese vats, cream cans and general dairy equipment.

Explosives — The titanium-bearing steels have proved over the years to be very satisfactory for resisting mixtures of nitric and sulphuric acid and have therefore been used extensively in nitration processes for explosives.

Cartridge Case Pickling — During the last war a considerable tonnage of the F.D.P. type of steel was used in plant for the pickling of brass cartridge cases. The strength of sulphuric acid used was higher than the steel would normally withstand. However, an addition of up to 1% of copper sulphate to a new solution inhibited attack and very satisfactory results were obtained.

The comparisons between 321 and 347 steels as regards welding and forming are interesting. Similar careful direct comparisons have not, so far as we are aware, been made in this country, primarily because the large majority of steel



Oxidizer Cooler at the Nitric Acid Plant of African Explosives & Industries, Ltd., South Africa. Constructed from titanium-stabilized steel in 1931

supplied for aircraft work is stabilized with titanium. During the late war my company produced a very large tonnage of the titanium-stabilized steel for use in aero exhaust manifolds, which gave very satisfactory service.

With regard to the effect of silicon content on the weldability of 321 steel by the oxy-acetylene process, it is not our practice to have silicon contents less than 0.5% — they generally lie between 0.5 and 0.8%. It is, of course, the general custom that columbium-stabilized filler wire or electrodes be used for the titanium-bearing steels and generally speaking it is considered that little, if any, difference exists in the weldability of the two types of steel. One feature which might be mentioned in connection with the oxy-acetylene welding of these steels is that better and smoother penetration is generally obtained with the titanium-bearing steels than with the columbium-bearing steels. This is because the somewhat more pasty nature of the molten metal produces a smoother underside of the welded joint.

It is interesting to note from the article that the titanium-bearing steel has somewhat better forming characteristics than the columbium-bearing steel. The general experience in this country is that the two steels are similar in this respect, but here again a careful comparison has probably not been made.

The presence of titanium-bearing inclusions, however, which are a characteristic of the titanium-bearing steels, and which often take the form of "stringers", can be detrimental in certain circumstances. Although no particular trouble from this cause has been experienced in drawing operations, these stringers can be troublesome when upsetting operations, either hot or cold, are involved on bar material. These stringers are apt to give rise to splitting in the upsetted portions of the bar, and for such applications we prefer to use the columbium-bearing steel.

The subject of creep is an important one and has many facets. The general opinion expressed in the article is that 347 is superior to 321 and, in general terms, we agree with this.

With regard to oxidation, we note that 321 is considered to be twice as resistant at 1850° F. as 347. Tests which we have carried out at 1470° F. (the maximum temperature

for which we would recommend either steel) indicated very little difference in the oxidation resistance of the two materials. As a matter of fact, there was a tendency for the columbium-bearing steel to be slightly better than the titanium-bearing material, but the degree of superiority was not really of significance.

The comments under the heading "Service Behavior" can be confirmed because all the types of components enumerated, as well as plant for many other applications, have been produced from the titanium-stabilized steels for many years in this country with satisfactory results.

C. SYKES
Director of Research
Brown-Firth Research Laboratories

Atomic Energy Applications

SCHENECTADY, N. Y.

In considering the relative merits of two materials such as Types 321 and 347 stainless steels, attention is usually confined to the conventional mechanical, physical and chemical properties. For many applications in the atomic energy field, however, there is at least one additional factor to be considered — the scattering and absorption of neutrons by the material.

These properties vary widely among the metals, and small amounts of an undesirable element in an alloy are deleterious enough so that a most detailed chemical analysis of the alloy is customary for their detection. For instance, the thermal neutron absorptions of the basic ingredients and the three stabilizing elements in stainless steel have the following relation (General Electric Chart of the Nuclides, 1950):

Iron	2.4
Chromium	2.9
Nickel	4.5
Titanium	5.8
Columbium	1.2
Tantalum	21

The higher the value given above, the less suitable is the element for some applications in a nuclear reactor. Thus, depending on the particular reactor for which stabilized stainless steel is being considered, design factors may limit the kind and amount of stabilizing elements that are permissible.

L. L. WYMAN
General Electric Co.

Pressure Vessels

JERSEY CITY, N. J.

Our company was among the first users of the stabilized type of austenitic steels some 20 years ago when both the columbium and titanium types were being made available to industry. At that time the mills were having difficulty in controlling the titanium content in the 321 steel; also, some heats contained excessive quantities of nonmetallic inclusions. These problems have long since been solved, but at the time users and fabricators of heavy sections began to standardize on the columbium-bearing type, with the result that Type 347 material has been commonly specified for pressure vessels, heavy fittings and in assemblies made of massive sections. As a result we find ourselves with comparatively limited experience with Type 321 steel. Data such as those presented by Mr. Tyrrell are therefore of interest to all fabricators of stainless steel, because the shortage of columbium can be expected to result in a wider use of titanium-stabilized steel.

H. S. BLUMBERG
The M. W. Kellogg Co.

Welding

MILWAUKEE

Our use of Type 321 stainless steel has been limited to laboratory studies but we have had extensive experience with Type 347. As pointed out by Mr. Tyrrell, there are differences in the welding of various heats of Type 347, and this is true of heavy plate as well as thin sheet. The presence of columbium carbide increases the hot shortness of the material and it is often necessary to preheat plates for welding in order to avoid cracking. Such preheating is usually done between 150 and 300° F.

In our experience the use of columbium in stainless steels such as Type 347 has not resulted in satisfactory weldments from the standpoint of *corrosion resistance* at the weld-to-stock junction after stress relieving at 1100 to 1250° F. This is caused by columbium going into solution in the parent metal heated to high temperature during welding, with the result that chromium carbides form in the sensitizing temperature range unless a stabilizing heat treatment at higher temperature (1550 to 1650° F.) is

given the weldment prior to exposure in the sensitizing range. The vendors of stainless steel are aware of this deficiency, which is characteristic in either Type 321 or 347, but as yet have no solution to prevent it for all heats produced.

We have had enough experience now with welding extra-low-carbon Type 316 stainless steel to conclude that it offers considerable advantage over the columbium-stabilized grades. As yet, experimental work on weld metal characteristics is insufficient to support final recommendations about electrode compositions. However, from the standpoint of corrosion characteristics, it seems that extra-low-carbon metallic electrodes could be recommended if the final product is to be heat treated at 1600°F. or higher and air cooled. If the weldment is to be stress relieved between 1000 and 1200°F., it would be necessary to use columbium-stabilized weld deposits.

We believe that a commercial extra-low-carbon grade of 18-8 would not sensitize in the manner described for Type 347; laboratory corrosion tests have demonstrated a freedom from "knife-line" attack. However, we are not certain that the extra-low-carbon grade would be satisfactory for exhaust manifolds, as it is generally not recommended for extended service above 800°F.

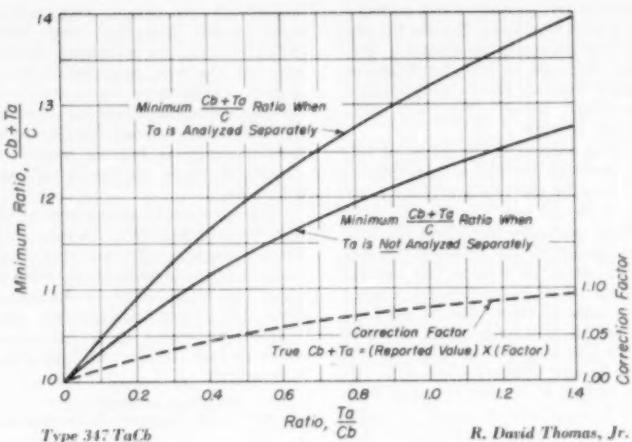
M. A. SCHEL
Director of Metallurgical Research
A. O. Smith Corp.

Type 347 Welding Electrodes

PHILADELPHIA

Mr. Tyrrell calls attention to the difficulty in employing Type 321 filler rods should the columbium shortage become critical, and properly infers that columbium-bearing weld metal should be employed for welding both 347 and 321 steels.

The welding electrode industry is well aware of the need to con-



R. David Thomas, Jr.

sider columbium and has been taking the necessary steps to insure the availability of Type 347 welding electrodes. The almost universal practice of the industry is to produce Type 347 coated welding electrodes by incorporating ferrocolumbium in the coating on a Type 308 wire (20% Cr, 10% Ni). The dwindling supplies of ferrocolumbium have necessitated an investigation to establish the feasibility of substituting the more readily available ferrotantalum-columbium alloy. Preliminary test results on the mechanical properties of welds have demonstrated that the substitution can be made without any sacrifice in the quality of the metal. Typical tensile values recently obtained are tabulated at the bottom of this page.

Standard accelerated corrosion tests are presently being conducted on these and other compositions of weld metal to ascertain the quality of the weld metal for corrosive service. An extensive program investigating the elevated-temperature properties of the weld metal is also being prepared.

The recovery of tantalum in the weld metal has been found to be

subject to the same variables as that of columbium, and to be about 70% of the value of columbium. Thus, with a given set of conditions, if columbium recovery is 65%, tantalum recovery will be about 45%.

It is well recognized that tantalum, because of its higher atomic weight, is only about half as effective as columbium in stabilizing carbon. Experience has dictated the desirability of a minimum ratio of columbium to carbon of 10; when a columbium-tantalum alloy is used, the equivalent ratio of columbium plus tantalum (analyzed together) to carbon is computed to be 11.4 for weld metal containing half as much tantalum as columbium. This equivalent ratio may be computed for any known ratio of tantalum to columbium which may be present. The accompanying curves may be useful not only to establish these minimum ratios but also to indicate the error that will be involved when columbium and tantalum are analyzed together, rather than undertaking the difficult and lengthy chemical separation.

R. DAVID THOMAS, JR.
Vice-President and Director
of Research and Engineering
Arcos Corp.

Chemical Composition and Tensile Properties of Weld Metal*

TEST NO.	C	Mn	Si	Cr	Ni	Cb + Ta†	HEAT TREATMENT	YIELD STRENGTH	TENSILE STRENGTH	ELONG. IN 2 IN.	R.A.
6804	0.068	1.61	0.55	19.96	10.25	1.05	As welded 4 hr. at 1300°F. 4 hr. at 1550°F.	75,000 psi. 75,000 66,500	97,000 psi. 103,500 95,500	33% 25.5 30.5	46.5% 37.5 48
6807	0.065	1.98	0.61	19.83	10.11	1.15	As welded 4 hr. at 1300°F. 4 hr. at 1550°F.	74,000 76,500 66,500	97,000 105,000 96,000	32 25 30	51 37.5 48

*All-weld-metal tensile specimens were 0.505-in. diameter. †Reported as Cb by conventional analytical methods.

Tantalum-Columbium

PIITTSBURGH

The new tantalum-columbium stainless steel is made with ferrotantalum-columbium alloy which contains about 40% columbium, 20% tantalum and 0.25% carbon, the remainder being chiefly iron. This ferro-alloy has been added to 18-8 in amounts that give a steel of nominal composition 18% chromium, 10% nickel, 0.6% columbium and 0.25% tantalum, with 0.06% carbon. Steels of this type have been tested at room temperature, 1000, 1200, 1350 and 1500° F. and as far as we are able to determine, their strength and ductility are comparable to those of Type 347 steel made with the regular ferrocolumbium alloy. The hot workability of the 18-8 steels containing columbium and tantalum is also comparable to that of the regular 347 steel.

In intergranular corrosion tests using acidified copper sulphate solutions, nitric acid solutions, and nitric-hydrofluoric solutions the resistance of the 18-8 steel containing columbium and tantalum to intergranular corrosion is equal to that of the regular 347. In fact, the 18-8CbTa steel having a columbium + tantalum content of at least ten times the carbon content has met all the corrosion requirements generally specified for 347, which shows that this steel is a good substitute for the regular Type 347.

RUSSELL FRANKS
Manager—Development
Electro Metallurgical Division
Union Carbide and Carbon Corp.

More on British Aircraft*

BRISTOL, ENGLAND

The British specifications covering weldable stainless steel sheets have hitherto quoted titanium and columbium only as optional elements, the main requirement of the specifications being that the material should withstand the weld decay test. It would be possible, therefore, for the supplier to furnish steel without either of the two elements, provided the carbon content was sufficiently low to avoid weld decay troubles. In actual fact the bulk of material supplied has contained titanium and in general this has given satisfactory results.

*See also discussion on p. 766, received too late for inclusion here.

A recent revision of these specifications has been made and now titanium or columbium in the appropriate amounts (depending on carbon content) is specified as an essential element.

E. R. GADD
Engine Division
Bristol Aeroplane Co., Ltd.

LONDON, ENGLAND

Mr. Tyrrell presents a good case for the diversion of columbium as a stabilizer for stainless steel to higher-priority demands as, for instance, its use in disk and blade alloys for gas turbine engines. Since the rating of critical alloying elements places columbium as the most scarce material, and with the present availability of titanium as it is, there is every reason for making a fuller use of titanium as a stabilizer for stainless steels.

At Napier's, where 18-8 stainless steel pressings are fabricated by torch welding methods, we have always accepted the titanium-inoculated composition as our standard quality. Over a long period our metallurgical laboratory has had no major problems to deal with concerning weld decay on components such as, for instance, exhaust stubs for one of our engine types. It is interesting to note that three grades of filler wire or rod have been employed for the welding of these exhaust stubs, one containing no stabilizer, one with a titanium addition and one with columbium. Any preference for a particular filler would appear to be a personal opinion on the part of the operator.

Where assemblies specified in 18-8 steel are fabricated by spot or stitch welding methods, again we use only the titanium-stabilized material. So far, no problems have been encountered in weldability.

Metal-arc welding is not applicable to the majority of our components where welding is called for. Where heavy-section stainless castings are welded by the metal-arc process we have a preference for columbium-bearing welding rods.

J. K. WILSON
Chief Metallurgist
D. Napier & Son, Ltd.

DERBY, ENGLAND

Utilization of columbium-stabilized stainless steels at Rolls-Royce, Ltd., has been negligible, but titanium-stabilized steels have been in production for more than 20 years.

Exhaust systems on automobiles, exhaust stubs and manifolds on aero piston engines, jet pipes, and exhaust cones and nozzles on jet engines have given satisfactory service up to 1400° F.

The titanium steels have been welded by all production methods — torch, arc (open and shielded) and electric resistance. Titanium steel sheet, 0.048 in. thick, is seam welded at 30 in. per min. to give a gas-tight joint. For torch welding, the titanium content must not be too high, to avoid sluggishness, nor too low to give an unstabilized weld deposit due to titanium depletion. For torch welding we confirm the author's finding that columbium electrodes are more consistent.

In general, U. S. steel manufacturers are able to supply stainless steels of lower carbon content than British firms, and the need for stabilization decreases with the lower carbon content. But even with carbon as low as 0.04% it has been our experience that stabilization is necessary for all welded parts or parts subject to service temperatures in excess of 1300° F.

H. E. GRESHAM
Chief Metallurgist
Rolls-Royce, Ltd.

BURNLEY, ENGLAND

Our experience covers the manufacture of exhaust units and jet pipes for gas turbine engines from sheet metal in gages varying from 0.032 to 0.064 in., for operation at temperatures from 1100 to 1300° F. In these units, we have used many tons of titanium-stabilized 18-8 sheet with complete satisfaction.

H. E. LARDGE
Joseph Lucas, Ltd.

WEYBRIDGE, ENGLAND

Stainless steels of the 18-8 type have been used by my company for exhaust manifolds for the past five or six years. During this period a number of failures have occurred and these can be attributed to the following causes: Inadequately stabilized material, faulty design, and faulty processing of the fabricated parts. Titanium is being used more generally than columbium and would appear to be quite satisfactory, providing the content does not fall below the recommended minimum of five times the carbon content. We have no reason to suspect that 18-8 steel fully stabilized with titanium is unsatisfactory for ex-

haust manifolds when used at temperatures of the order of 1200° F.

Failures of manifolds have often been attributed solely to the use of unsuitable material, but in fact the contributory causes have been faulty design and inadequate processing of the fabricated parts. The gage of material is often too thin and insufficient provision is made for the free displacement of the unit when submitted to thermal stresses.

The omission of annealing before and after welding has led to cracking of the manifolds, while the lack of adequate surface preparation has resulted in faulty welds.

J. H. CORK
Aircraft Section
Vickers-Armstrong, Ltd.

BELFAST, IRELAND

In stabilized chromium-nickel heat resisting steels of the 23-18 and 23-14 types made to British Standard Specifications S108 and S109, the titanium and columbium contents are respectively 4 and 8 times the carbon content of 0.2% max. However, better proportions would be 5 and 10 times carbon, to ensure sufficient stabilizing effect when the carbon is at its top limit.

R. E. PACKER
Seaplane Works
Short Bros. & Harland, Ltd.

COVENTRY, ENGLAND

To most English readers, Mr. Tyrrell's informative article will be of interest in that it justifies a practice long established in this country — the use of titanium in preference to columbium as the stabilizing element in austenitic stainless steel, particularly in the aircraft industry. To have insisted on columbium-stabilized sheet during the war would have caused grave difficulties in supply; nor was there ever any convincing evidence that subsequent manufacture would have benefited or reliability increased, at least so far as aircraft were concerned.

Chemical analyses covering a very large number of production supplies delivered to our works over many years show that almost all of the austenitic steel sheet purchased in conformance with the weld decay test has been stabilized with titanium. It would be futile to pretend that we had no trouble with any of this sheet but I cannot recall a single instance of trouble in service or production in which there was any evidence that changing over to

columbium-stabilized sheet would have got us out of our difficulty.

In service most of the failures were caused by fatigue or by various troubles associated with overheating (primarily excessive oxidation and attack from exhaust gases and corrosive deposits). Creep failures and failures resulting from alternating thermal stresses have arisen less frequently. Most troubles were overcome by design alterations such as the elimination of vibration, improvements in the fatigue strength of the structure, and greater cooling. Change of material was made only on rare occasions and when definite evidence for its desirability was forthcoming and in such cases the changes were to materials of basically different composition.

Columbium-stabilized sheet is made over here, of course, but usually for special purposes. For example, one of the largest steel firms supplies it in view of their claim that it gives somewhat better creep properties over a certain temperature range.

All this is in agreement with the observations and laboratory tests mentioned by Mr. Tyrrell. I would add that we have carried out cracking tests on sheet test pieces under conditions of alternating thermal stresses and that these show no advantage for the columbium-stabilized material. High-temperature fatigue tests have indicated no apparent difference and creep-to-rupture tests on welded test pieces have shown that variations in the welding technique, rod and flux composition completely mask the effect of differences in the base metal composition of the type under discussion.

These remarks apply to wrought material. The position is not quite the same when we come to the question of castings. Centrifugally cast rings for turbine shrouds, for instance, are, if made of 18-10 material, usually stabilized with columbium. This is entirely a matter of preference on the part of the foundries, which report greater difficulty in the production of metallurgically clean castings and control of composition when using titanium. Nevertheless, titanium-stabilized castings are being made and one of the foremost manufacturers in this country has pointed out that while in general he much prefers to use columbium, the use of titanium may be of advantage because less trouble is encountered from hot cracking. This

point may be related with that made by Mr. Tyrrell concerning the hot cracking of welds.

My impression is that in Britain we are very much more titanium conscious in a number of respects. Mr. Tyrrell mentions the large amount of columbium being used in gas turbine parts in America. This is not so in Britain. Almost all our jets and prop-jet engines are fitted with Nimonic 80 or 90 blades which are hardened with titanium. Austenitic turbine disks containing columbium have been widely used over here but alternative austenitic steels free from columbium are now available and there is a general tendency to go over to ferritic steels containing no columbium, or in amounts very much less than are added to the austenitic steel mentioned above. Some firms have in fact been using columbium-free ferritic steels for turbine disks all along. It would hardly be an overstatement to suggest that, with the exception of certain welding rods, columbium could be eliminated completely from our highest-powered jet engines with no marked effect on the manufacture or performance.

S. T. HARRISON
Chief Metallurgist
Armstrong Siddeley Motors, Ltd.

Back to the States

CHULA VISTA, CALIF.

Type 347 steel has been increasingly preferred for years despite its higher cost, as compared to Type 321, when a stabilized variety of 18-8 was required.* Examination of many heats of Type 321 at Rohr Aircraft Corp., over a period of years, has demonstrated the inability of titanium to provide proper and consistent stabilization after exposure to sensitizing temperatures.

*EDITOR'S NOTE: The extent of this preference during recent years may be judged by the following figures for production of stainless steel ingots of the two types. Data were reported by the American Iron and Steel Institute. Note high production of Type 321 during wartime and the change back to 347 in 1946.

	TYPE 347	TYPE 321
1942	29,755 tons	53,525 tons
1943	33,064	60,145
1944	26,988	61,641
1945	32,364	37,338
1946	16,113	3,555
1947	22,966	6,949
1948	33,346	7,528
1949	26,710	5,575
1950 (a)	17,470 (a)	3,616 (a)

(a) For first six months only.

Using Type 347, we have been able to produce high-quality stabilized welds more consistently and at greater speeds than was possible with 321. Type 321 rods are not used because of the "burning" of titanium. The welding of "standing edge" joints, which do not require rods, is not recommended for the same reason.

The successful forming of many intricately shaped parts at Rohr from 347 rather than 321 can be explained, in part, by the fact that the columbium variety is generally "cleaner" metallurgically, as observed during many microscopic examinations.

BERNARD GROSS
Director of Laboratories
Rohr Aircraft Co.

Drawn Tubing

NORRISTOWN, PA.

It is no secret that the stabilized varieties of stainless steel have frequently shown poor performance in exacting mechanical applications because of an unusually high content of nonmetallic inclusions. Much progress has been made during recent years in cleaning up the titanium-stabilized 321, as indicated by the typical micrographs in Fig. 1. The columbium-stabilized 347 has not suffered so much from this defect, but the average inclusion rating of 347 has, nevertheless, been a matter of concern in some uses.

Precision tubing has recently been drawn from both seamless and "Weldrawn" stock in the new tantalum-columbium variety of 347.

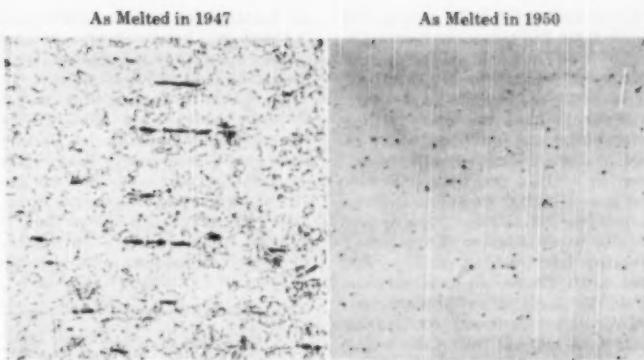


Fig. 1 — Inclusion Content of Type 321 Seamless Tube. (Left) Electrolytic oxalic acid etch; 125 \times . (Right) Unetched; 100 \times

Because of the greater amount of stabilizing elements present in this steel it might be expected that the inclusion rating would suffer. However, the inclusions in 347TaCb, though of slightly different form, seem to be present in no greater quantity than in the 347Cb (Fig. 2).

In workability and weldability we find little to choose between the regular 347 and its tantalum-bearing congener. The simple Strauss test has been met as satisfactorily with tantalum-bearing 347 as with the regular type, at least where the columbium-to-tantalum ratio is approximately 4 to 1. Cooperative efforts among many laboratories will be required before one can know the differences and similarities between 347Cb and 347TaCb in specific corrosion resistance and high-temperature strength.

Our own experience so far is limited to three heats melted by different producers, and that experience has been wholly satisfactory.

D. H. WIESE and H. W. COOPER
Metallurgical Department
Superior Tube Co.

Hot Workability

MILWAUKEE

Mr. Tyrrell mentions the red shortness of Type 347 steel in his discussion of the cracking of welds but does not refer to this difficulty in other hot fabricating operations. We have investigated both of the stabilized grades of stainless steel by means of the hot twist test developed in the laboratories of Globe Steel Tubes Co., and results have been published in *The Iron Age* (April 20, 1944) and the *A.I.M.E.*

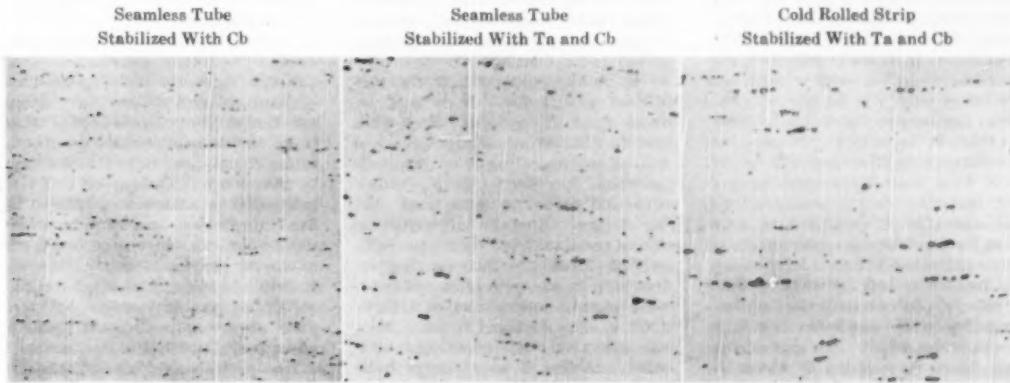


Fig. 2 — Inclusion Content of Type 347 Stainless Steel. 100 \times . (Left) Unetched. (Center) Longitudinal section; electrolytic oxalic acid etch. (Right) Longitudinal section; unetched

Transactions (Vol. 167, 1946, p. 749 to 790). In the latter publication, a graph was included showing the spread of results for ten heats of Type 321. Those data and other evidence indicate the necessity for determining the hot workability of each heat of steel individually. However, as a class, the Type 321 steel has much better hot workability than Type 347. Thus, there would be less scrap loss in the piercing or other hot working of Type 321 than with similar operations on Type 347. Such scrap cannot be remelted under ordinary oxidizing conditions without losing the major portion of the scarce columbium.

HARRY K. IHRIG
Vice-President
Globe Steel Tubes Co.

Again—When Is a Stabilized Steel Necessary?

CANTON, OHIO

Mr. Tyrrell has presented much pertinent information as the basis for his conclusion that Type 321 is a suitable replacement for Type 347. However, his statements with respect to the high-temperature properties of these steels might well be expanded.

Thus, Table III of his paper gives the reported stress ranges for 0.0001% creep per hr. at a series of temperatures and also shows an average value. It is questionable whether this average has any meaning. We have found that apparent grain size has a pronounced influence on all the high-temperature properties of these *stabilized* grades and consequently the grain size should be reported with any high-temperature data (*A.S.M. Transactions*, Vol. 38, 1947, p. 148 to 179). For example, there is greater difference between 347 with a grain size of 8 and with a grain size of 2 to 4 than between many radically different steels or alloys. It does not necessarily follow that 321 or 347 will have high-temperature properties superior to the standard 18-8, because similar variations in grain size have relatively slight effects on the unstabilized steel.

Insofar as ease of working these steels is concerned, the author's remarks were confined largely to room temperature. The accompanying figure is included to show the differences in their hot twist characteristics over the temperature range used for hot processing, such

as forging and piercing into seamless tubes. Thirty heats of each grade were considered and, as would be expected for steels of this type, there is considerable spread in both the number-of-twist and torque values, even though each of the heats was properly balanced to prevent the formation of free ferrite at the hot working temperatures. However, the figure shows that, in general, 321 has the greater number of twists to fracture and also has

pronounced structural changes occurred, accompanied by intergranular carbide precipitation. We have examined 18-8 tubes after 100,000 hr. of service and found no indications of excessive intergranular oxidation or corrosion (*A.S.M. Transactions*, Vol. 35, 1945, p. 298-330). It is true that if a corrosive condensate is permitted to form, intergranular attack may occur at room temperature or slightly above, but there are often procedures that may be followed to prevent the formation of this condensate.

Wherever possible the standard 18-8 analysis should be used, for this is still the most foolproof of all the austenitic grades. Its hot workability is certainly superior to the stabilized grades, its mechanical properties at elevated temperatures are independent of many variables that influence the stabilized grades, and it is generally much freer from surface or subsurface imperfections.

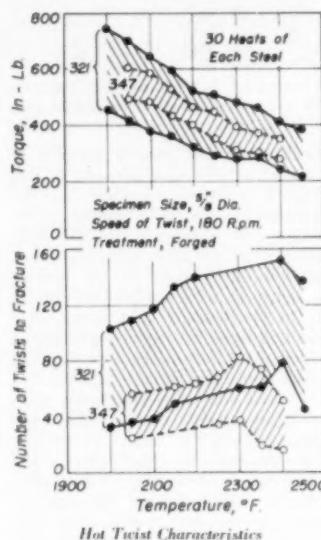
C. L. CLARK
Metallurgical Engineer
Timken Roller Bearing Co.

Once More—When Is a Stabilized Steel Necessary?

PITTSBURGH

We believe that discussion of columbium conservation is timely and useful, particularly if it leads to ways and means that will effect reductions in the use of this critical element. Rather than to discuss Mr. Tyrrell's article, in which he very ably outlines his experience in the use of both columbium and titanium-bearing compositions, we propose that consideration be given to the possibility of conserving columbium by other means.

During the course of our association with the requirements of stainless steels for high-temperature systems in aircraft, we have often questioned the requirement that these stabilized materials must contain sufficient amounts of columbium or titanium to enable them to resist intergranular attack as evaluated in the laboratory by exposure to selective boiling corrosive solutions, such as copper sulphate-sulphuric acid. In other words, we ask: Is the ability of stainless steels to meet these severe embrittlement tests in any way related to the performance of these steels in high-temperature service? Is it not probable that smaller amounts of these additions would provide steels that are equally



satisfactory? Indeed, is it not possible that just plain old-fashioned 18-8 would give as good account of itself as its stabilized modifications?

The basis for our reasoning may be summarized as follows:

1. We have observed that most of the failures of exhaust systems returned to our laboratories for investigation have been of a fatigue type which in our opinion was not associated with the ability of the material to meet the embrittlement test.

2. Mr. W. G. Hubbell in another very pertinent article, "Effect of Stabilizing and Stress Relief Heat Treatment of 18-8 Stainless" (*Steel*, August 25, 1947), reports his findings on stabilized material from exhaust systems which had been in service for as long as 4000 flying hours. His investigation shows no correlation between the service life of such materials and their ability to meet the embrittlement test.

3. Such compositions as 25-20 and 25-12 containing carbides in the grain boundaries (to the extent that the steels are susceptible to intergranular corrosion by selective wet corrosive reagents) have been used in high-temperature systems of aircraft and have performed well.

4. Exhaust systems of military aircraft (even fighter planes exposed to corrosive salt atmospheres) were shrouded with Type 302 steel during the last war. We have observed heat tint and oxidation on such shrouding to a degree that suggests that the shrouding was subject to operation in the carbide precipitation range. Apparently such material was satisfactory and did not fail by intergranular corrosion.

5. Intergranular attack may result from causes other than chromium carbide precipitation. For example, we have observed intergranular attack induced by the deposition of the lead compounds which result from the combustion of leaded fuels. The use of columbium or titanium does not inhibit such attack.

The foregoing comments are offered with the recommendation that, in the interest of conservation, investigations should be undertaken to establish the relative merits of materials under actual conditions of service. These investigations, we believe, should include the unstabilized as well as the stabilized grades of 18-8 stainless steels, with varying amounts of columbium or titanium.

We are not aware of any systematic investigation that supports any

correlation of corrosion tests with service performance. We suggest, therefore, that unless such studies have been made or until they are made, under conditions closely associated with those of flight and field service, we may be perpetuating the use of critical materials where they are not needed.

D. C. BUCK
Metallurgical Engineer
Carnegie-Illinois Steel Corp.

Intergranular Cracking in Aircraft Parts

WASHINGTON, D. C.

I concur heartily with Mr. Tyrrell in emphasizing the importance of conserving columbium now, wherever possible. His thesis—the rather general substitution of titanium-stabilized stainless steel for the columbium-stabilized type—is unlikely to be accepted unanimously, for this subject is one of perennial debate. Numerous denials notwithstanding, there seems to be a definite prejudice against such a substitution, often for reasons rather dubious and ambiguous. There is a legitimate question, however, as to whether the two steels are always interchangeable with respect to serviceability, and each significant type of application should be judged on its own merit.

One point regarding interchangeability is often misunderstood and warrants clarification. I refer to the question of government specifications. In spite of the above question as to complete interchangeability, the Air Force - Navy specifications for aircraft and related items include both compositions of steel in all stabilized stainless steel specifications, and both types are acceptable on an equal basis. Stated somewhat differently, the prime contractor is given complete freedom to use either type for a given application. The Bureau of Aeronautics has, in fact, urged its contractors to select the Type 321, unless the contractor considers this type unsuitable in a specific application.

The generally satisfactory service performance of stabilized stainless steel resulting from the above policy on interchangeability speaks for itself. In a similar manner, the Bureau of Aeronautics has indicated its willingness to accept columbium-tantalum combinations, in accordance with applicable specifications, as a completely interchangeable

alternate, except in stainless welding rod, where, pending compilation of necessary data, columbium is still required. It may be anticipated, however, that columbium-tantalum combinations (at least up to about one-third tantalum) will eventually prove to be acceptable in welding rod also.

Mr. Tyrrell has very ably and convincingly discussed several factors relating to selection of a stabilized type: Welding characteristics, forming, casting, and several engineering properties, particularly creep and short-time tensile strength. Other factors that must be considered in many designs are: Resistance to intergranular corrosion and embrittlement, long-time rupture and fatigue resistance at various temperatures, ductility (beyond elongation), surface condition, freedom of final product from inclusions and segregates, and cost. I would like to take this occasion to discuss intergranular attack, omitting the other factors in the interest of brevity.

Extensive work has been done on steels "sensitized" from about 900° F. upward, to determine their resistance to copper sulphate solutions as a measure of resistance to intergranular corrosion and embrittlement. Let us defer for a moment the question of significance of these tests. An excellent summary of recent data is given by S. J. Rosenberg and J. H. Darr in *A.S.M. Transactions*, Vol. 41, 1949, p. 1261. From these data it is evident that resistance to the copper sulphate test is generally inferior in Type 321 steel unless adequate precautions are taken to have a high ratio of titanium to carbon (upward of 6:1), or unless a "thermal" stabilization at approximately 1600° F. for about $\frac{1}{2}$ to 1 hr. is given. Previous thermal and mechanical history is important. It is worth repeating, however, that where the Ti/C ratio is high enough, results comparable to Type 347 are obtained.

The question that logically follows is, briefly: "So what?" The same question has been asked, incidentally, concerning the significance of endurance limit of carefully polished specimens, the transition temperature of steels, notch-impact strength, tensile elongation in a 2-in. specimen, and a host of other properties, but it may be that any similarity between these questions is purely coincidental. Certainly the

hazard in extrapolating from empirical laboratory tests—particularly corrosion tests—to service operation is well recognized and cannot be overemphasized. Nevertheless, other things being equal, poor results in any of the above properties may be a danger signal that should not be disregarded without careful consideration. Conversely, if it is practical to avoid these danger signals where they might be applicable, regardless of their real significance, the user may have more confidence in his product, a bigger "factor of safety", so to speak.

The desirability of such a safety factor, when feasible, has often been

Another favorite question relating to intergranular corrosion is: "What is the minimum ratio of titanium to carbon necessary for practical immunization?" Normally, a ratio between 5 and 7 seems to be preferred. The following service experience may be of interest, although I have deliberately avoided any positive conclusion with respect to the interrelation between titanium-carbon ratio, intergranular attack and service correlation with laboratory results, due to several possible explanations of varying probability.

This example refers to airplane exhaust manifolds which had cracked

titanium/carbon ratio of 5 (or even 4) has often been stated as satisfactory based on extensive experience, these values were primarily the minimums in the applicable specifications, whereas the values in the material actually used have generally been higher. Note, for example, that Mr. Tyrrell gives results of statistical analysis of 77 heats indicating an average titanium/carbon ratio greater than 9.

It would appear, in recapitulation of the above, that the substitution of titanium-stabilized steel for the columbium type is generally either permissible or warrants serious consideration. Nevertheless, from the point of view of serviceability, the specific requirements of the application must be carefully evaluated or a preliminary service test must be conducted before final decision is made. Where deteriorating influences exist, adequate stabilization must be insured, either through the medium of adequate titanium/carbon ratios or thermal stabilization; otherwise, the conservation of a small amount of stabilizing element may require payment in terms of replacement of an entire component, involving considerable critical alloy, man-hours, disability of equipment, money and perhaps more disastrous results. Thus, it is extremely difficult, to say the least, to present *a priori* any extensive list of applications where steels properly stabilized with titanium and properly processed would be unsatisfactory, except possibly to stress the need for caution in high-temperature applications involving gas welding, continuing high or vibratory stresses or highly deteriorating environments.

Another question that has often been raised is whether stabilized grades are necessary at all for high-temperature operation. The preceding paragraphs in this discussion and additional data, definitely preclude any categorical statement that stabilized steels are unnecessary. It is true that in certain applications involving moderate time, temperature and exposure conditions, low-carbon (0.03% max.) stainless may be entirely suitable. As previously stated, the specific type of application must first be studied or service-type tests conducted. It is as unjustified to arbitrarily apply conclusions from one set of operating conditions (perhaps only partially definable) to another type of



Fig. 1—Cracks in Exhaust Manifold (Type 321 Steel) Apparently Originating at Areas of Interganular Attack on Inside Surface. Note region of abnormal grain size. Etched electrolytically in chromic acid; 100 \times

illustrated. For example, in one service experience, Type 316 steel was used in a high-temperature supercharger application, and normally operated satisfactorily, but just on the margin of what is usually considered the sensitizing temperature range. Due to a change in related equipment (heat exchanger) and operation, the operating temperature of the component in question dropped to approximately 1300°F., with subsequent intergranular attack, embrittlement and failure of the steel. An original, relatively inexpensive, extra precaution of using a well-stabilized steel, possibly with molybdenum added, would have paid dividends in avoiding any necessity for expensive, time-consuming material changes.

and then partially broken off in service. Analysis showed some of the steel involved to be Type 321 with carbon approximately 0.09% and titanium/carbon ratio approximately 8. Thus a high degree of immunity to intergranular corrosion would have been expected, at least on the basis of accelerated laboratory tests.

The major cracks appeared to be the result of stress corrosion but study of the inside surface exposed to exhaust gases showed the origin of the cracks to be intergranular (Fig. 1), becoming transgranular as they progressed. Thus intergranular attack appeared to be the original cause which led to the ultimate failure, by serving to concentrate the stresses. Although a

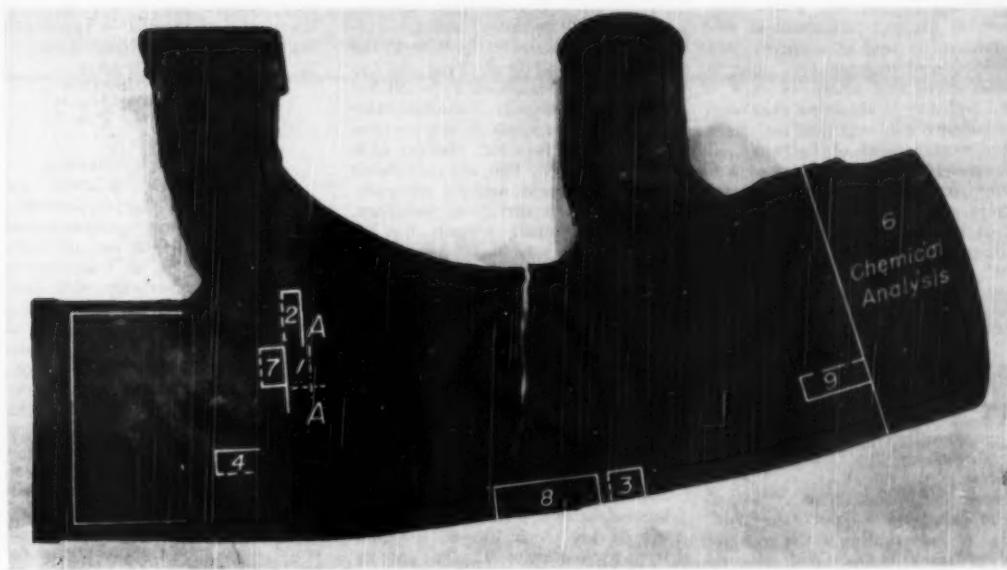


Fig. 2 — Appearance of Failed Exhaust Collector Ring As Received for Investigation. Failure occurred in portion made of unstabilized stainless steel. Numbered areas indicate sections taken for test. Dotted lines indicate planes on which micro-examinations were made. Component is shown at about 2/5 actual size

application as it is to extrapolate from accelerated laboratory tests, but too often this is done.

Again by way of example, it appears that the petroleum industry utilizes unstabilized stainless successfully at high temperatures. Yet, a number of aircraft exhaust components made in part from unstabilized steel and in part from stabilized steel, have failed in service completely in the unstabilized portions. Figure 2 illustrates how the unstabilized material cracked and broke away. Figure 3 shows the severe intergranular corrosion found on the inside surface of the unstabilized steel only. Nevertheless, the low-carbon unstabilized stainless may be substituted in a number of less critical applications, and in any case, the melting of lower-carbon stabilized stainless permits conservation of columbium per se, as well as, alternatively, the use of high titanium/carbon ratios while still retaining low titanium content, with possible advantages in improved cleanliness and ductility.

It would seem feasible, also, to produce at least a substantial percentage, if not all, of the required amount of low-carbon stainless in an emergency, in spite of potential

shortages of low-carbon ferrochromium, particularly when it is recalled that in one current large-scale process of producing stainless, utilization of direct reduction of chrome ore obviates the need for low-carbon ferrochromium.

In conclusion, the substitution of Type 321 for 347 offers greater promise than any other single measure for conserving columbium. Additional columbium can be conserved by lowering the carbon *in the stabilized grades*, by using the unstabilized 0.03% carbon maximum type in some components, by using

columbium-tantalum stabilizing combinations, and even by using columbium-titanium stabilizing combinations, for which favorable data exist. It appears highly significant also, based on Mr. Tyrrell's data, that 85% excess columbium is used over what is actually called for.

Important end-uses must be studied carefully, however, and the selection of material must be based on the requirements of the individual uses. Sometimes only service tests will give the positive answer.

The above discussion has been slanted toward the more critical ap-

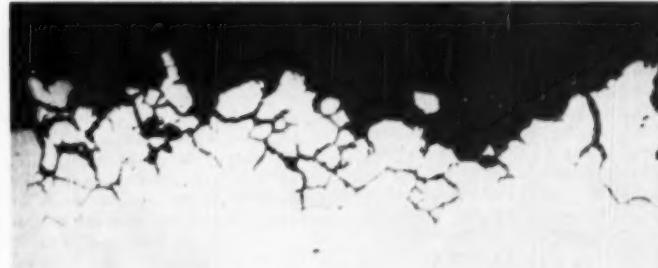


Fig. 3 — Severe Intergranular Corrosion at Inside Surface of Unstabilized Steel in Failed Collector Ring Shown in Fig. 2. Unetched; 100X

plications in aircraft, where jeopardy of life and fulfillment of vital missions, as well as economy, production and maintenance, must be considered; and where, in view of the difficulty of obtaining conclusive experience data and positive, exclusive explanations of failures, all danger signals must be viewed with concern. Obviously, there are many simpler applications of stainless steel where such detailed considerations are not necessary.

N. E. PROMISEL
Head, Materials Branch
Navy Bureau of Aeronautics

Stabilized Castings

MINEOLA, N. Y.

Very limited quantities of titanium-stabilized castings have been produced by the alloy casting industry in the United States. Conversely, production of columbium-stabilized castings of the CF-8C type (corresponding to the wrought alloy Type 347) has shown a steady increase in tonnage as well as in percentage of total output. The following tabulation of shipments shows the growth in demand for stabilized alloys in the postwar years. The increase in 1949 is especially significant because the total output of corrosion resistant castings declined in that year with respect to 1948.

	CB TYPE	TI TYPE
1946	485,000 lb.	160 lb.
1947	461,000	1650
1948	505,000	†
1949	834,000	†
1950*	710,000*	†

*First 7 mo. (est.) †None reported.

In view of the present necessity to eliminate columbium from all but the most essential uses, it is encouraging to learn from Mr. Tyrrell's article that Solar Aircraft Co. has made a successful start on overcoming previous objections relating to production of titanium-stabilized castings in the foundry. Although the stabilized cast alloys were studied in past research programs, the Technical Research Committee of the Alloy Casting Institute recently began a new project at Battelle Memorial Institute directed toward a more extensive investigation of the corrosion resistance and castability of titanium-stabilized compositions.

E. A. SCHOEFER
Executive Secretary
Alloy Casting Institute

BIRMINGHAM, ALA.

The steel and alloy casting foundries have generally preferred the columbium-stabilized Type 347 to the titanium-stabilized Type 321 for three reasons: (a) Titanium-stabilized stainless steels do not perform well in the Huey test (boiling 65% nitric acid), (b) they are considered difficult to weld without adversely affecting their corrosion resistance, and (c) titanium is easily lost by oxidation in the ladle or during pouring.

None of these is a conclusive reason for not using the titanium-stabilized steels. The Huey test is a test for the resistance of a metal in boiling 65% HNO_3 only, and tells nothing about its resistance in other media; it is known that the titanium-stabilized steels are quite resistant to many media. Welding with titanium-stabilized rods has not been successful but with columbium-stabilized rods there should not be too much loss of titanium from the parent metal. The loss of titanium in the ladle and during pouring can be compensated for by careful practice. Therefore, for many services, the objections are nonexistent or can be overcome, and Mr. Tyrrell's point for conservation is well taken, especially in view of the considerable advantages for the titanium steels which he has pointed out.

CHARLES K. DONOHO
Chief Metallurgist
American Cast Iron Pipe Co.

ELYRIA, OHIO

I believe the points made by Mr. Tyrrell are well taken. In my opinion, there is no reason why the titanium-stabilized material should not be a logical substitute for elevated-temperature service where creep strength and hot gas corrosion resistance are predominating significant properties.

We know from our experience and data that additions of columbium to the 18-8 and 25-12 types of alloy castings impair oxidation resistance severely. The adverse effect of titanium is much less.

Because of the common idea that titanium impairs the fluidity or foundry handling characteristics of stainless and heat resistant alloys, we have not experimented with it to any appreciable extent. It is unlikely that these troubles are severe, and our company, as well as many other producers of alloy castings,

will devote considerable effort in the next few months to investigating the titanium-modified alloys.

N. A. MATTHEWS
Division Metallurgist
Electro-Alloys Division
American Brake Shoe Co.

DETROIT

As Mr. Tyrrell indicates, the present necessity for conservation of columbium requires a reappraisal and an investigation into alternate practical methods of stabilization.

Our own experience with titanium stabilization is somewhat limited; however, early attempts at the production of titanium-stabilized castings indicated a fluidity problem and, as Mr. Tyrrell has mentioned, some "fading" of titanium. The mechanical properties of cast titanium stainless have been found entirely satisfactory and tests in our laboratory check those of the author very closely.

It would appear that Mr. Tyrrell could offer a distinct contribution by elaborating on his methods of producing castings, particularly as regards the manner of introducing titanium into the melt, the recovery of titanium both from the ferro-alloy and from titanium-bearing scrap, and the fluidity and casting characteristics experienced.

R. J. WILCOX
Technical Director
Michigan Steel Casting Co.

SHEFFIELD, ENGLAND

We unfortunately have no easily available statistics at our disposal to demonstrate the relative extents to which columbium and titanium have been used now or in the past in this country, but I think we can say without doubt that, insofar as steel castings are concerned, there has been a marked preference over the last ten years or so for columbium.

It seems equally certain that this preference is the result of the better fluidity and the better mechanical test figures steel founders normally obtain from the columbium-treated steels on the one hand and of the relatively high losses of titanium during steelmaking on the other. In addition, many producers have found greater difficulty in meeting the copper sulphate - sulphuric acid test when using titanium.

It must of course be said that these alleged disadvantages of titanium have been magnified by the

(Continued on p. 742)

The perchloric-acetic electrolytic method is superior to mechanical polishing and chemical etching for zirconium and zirconium-uranium alloys.

Metallography of Zirconium

■ INCREASING INTEREST in zirconium for many applications beyond the small amounts used in deoxidizing steel has created a need for methods of evaluating the structure and properties of the metal and its alloys. The metallography of zirconium — like all metallography — has two related but distinct problems. One is the preparation of surfaces for microscopic examination; the second, interpretation and standardization of structures. Satisfactory progress has been achieved along both lines, particularly the first.

Zirconium resembles other rare metals closely, but certain characteristics of it render ineffective the methods ordinarily used in sample preparation.

NOTE: This work was carried out at the M.I.T. Metallurgical Project under Contract No. W-7405-eng-175 with the U. S. Atomic Energy Commission.

tion. In this laboratory, mechanical polishing and chemical etching never seemed to produce optimum results. A variation of the perchloric-acetic electropolishing method has been found most useful for zirconium and many of its alloys.

The procedure outlined here is fast and fairly simple. Preparation of the sample, prior to electropolishing, consists of customary paper grinding, finishing with grit 3/0. Anything finer than 3/0 tends to smear zirconium rather than to cut it. Samples are unmounted, providing good electrical

By H. P. Roth
Metallurgical Project
Massachusetts Institute of Technology

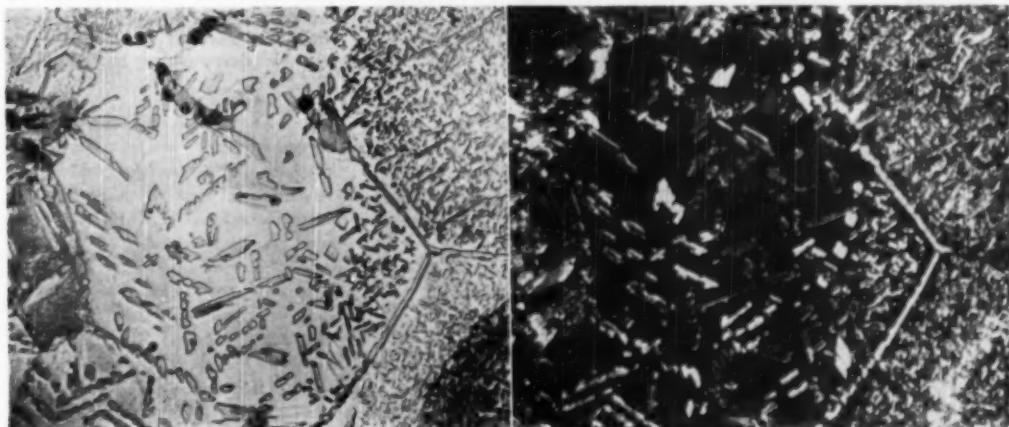


Fig. 1 — Zirconium-Uranium Alloy Containing 22.3% Uranium. Held 6 hr. at 1380° F. and brine quenched. Same area photographed in bright light (left) and polarized light. 250×

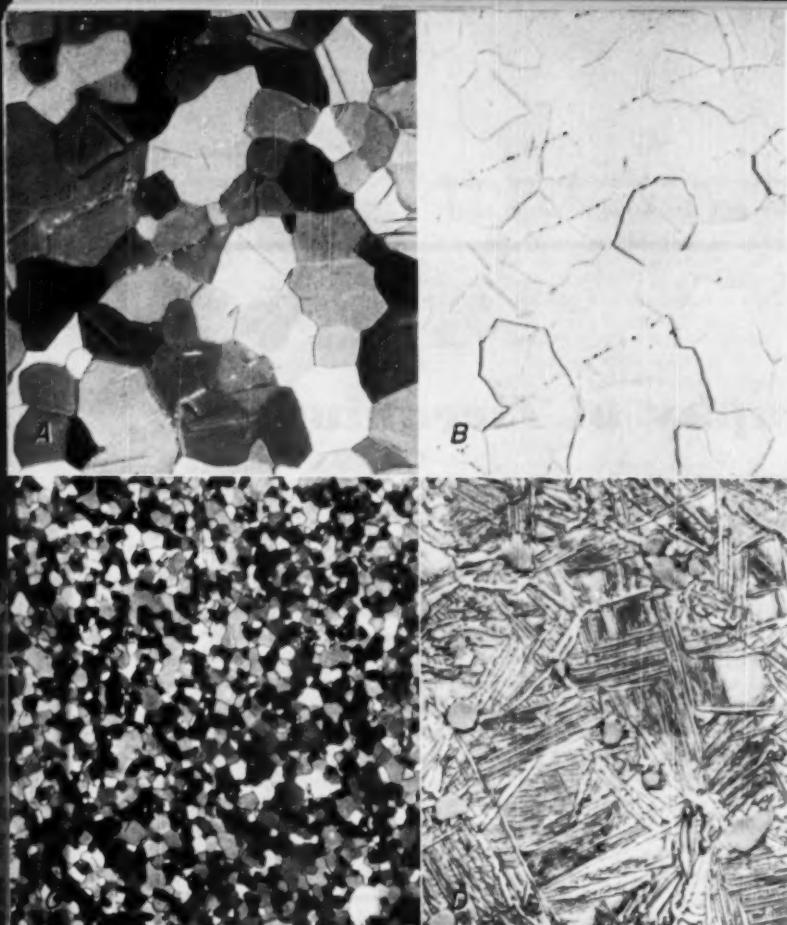


Fig. 2 — All Transverse Sections. (A) "Crystal bar" machined to a round, cold swaged slightly and annealed 2 hr. at 1830° F., subsequently cold swaged to 25% reduction in area and annealed 4 hr. at 1290° F. to recrystallize. Fine carbide stringer formations occur along certain planes within primary crystals. Often such inclusions have a marked effect on new crystal formation and growth in zirconium. (B) Same area. (C) Tubing extruded from cast crystal bar zirconium. (D) Zirconium-uranium alloy containing 19% U with 0.5% C, heated during dilatometric testing to 2060° F. and slowly cooled. The clear, gray globular masses are carbides. Micrographs on left made with polarized light; the other two, with bright light. Magnification 250×, except (D), which is 500×

Most of the zirconium produced in the U. S. is made by two processes, although others have been devised. One reduces zirconium tetrachloride by molten magnesium; this product, as currently made by the Bureau of Mines, consists of a dense sponge. The other process, from which the purest metal is obtained, is the iodide method. Crude powder or lump zirconium is placed in a chamber containing a hairpin filament connected to electrodes. After evacuating and heating, iodine is admitted and the resulting reaction deposits zirconium on the hot filaments. The product is often referred to as "crystal bar", because it appears to be many angular crystals of medium size, haphazardly piled up to form shiny, irregular rods.

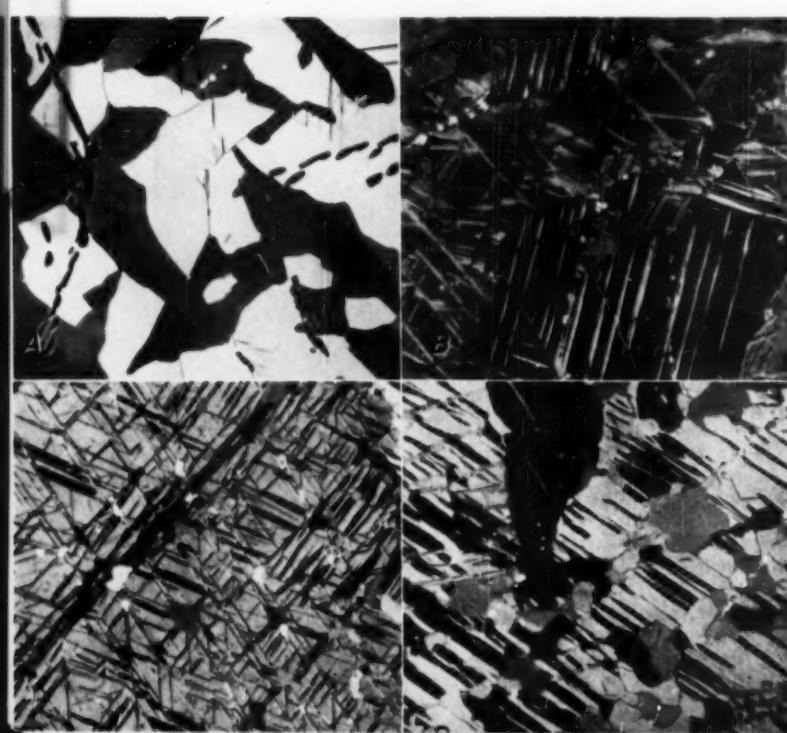


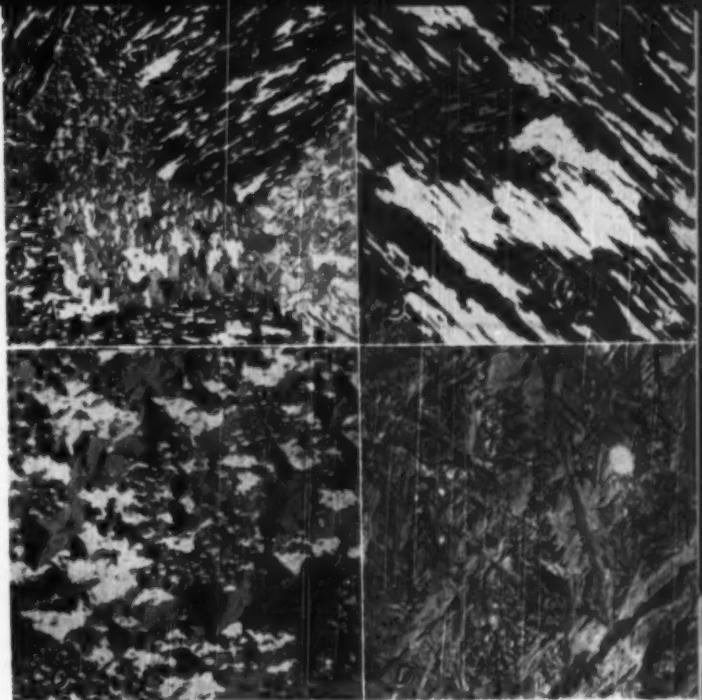
Fig. 3 — Transverse Sections. (A) Bureau of Mines zirconium melted in graphite. (B) Crystal bar swaged to a reduction in area of 6.7%; typical worked structure. (C) and (D) Same metal annealed for 6 min. in lead bath at 1200° F. after swaging. These specimens show recrystallization beginning along deformation bands similar to occurrences observed previously in uranium (see Metal Progress for November 1949). All micrographs made with polarized light. Magnification 250×, except (C), which is 100×. Prepared for R. M. Treco in an investigation on the recrystallization of zirconium.

Fig. 4 — Transverse Sections. (A), (B), and (C) are from the same specimen of Foote crystal bar machined to a round, cold swaged slightly to induce recrystallization, annealed 2 hr. at 1830° F. and slowly cooled. Specimen was then reduced 39% by cold swaging, heated to 1830° F. in purified argon and brine quenched. (D) Crystal bar cold swaged to about 20% reduction in area and water quenched from above 1830° F. All micrographs made with polarized light. Magnification 250×, except (A), which is 100×

contact. This also keeps bakelite out of the bath and eliminates the possibility of explosion. (Any reader seeking reassurance concerning the safety of perchloric-acetic acid solutions may refer to the excellent article by P. A. Jacquel, *Metal Finishing*, November 1949, p. 62.)

The electrolyte consists of one part 60% perchloric acid to ten parts glacial acetic acid. This solution can be prepared in a few minutes and used immediately. About 300 ml. total volume is usually sufficient. The life of the bath permits polishing of 30 to 35 samples of approximately $\frac{1}{4}$ in. square, or about $\frac{1}{2}$ sq.in. of total surface area immersed. Larger pieces can be polished by varying the current density.

The cathode is a strip of stainless steel placed horizontally about an inch below electrolyte surface level. The portion of the sample requiring polishing is immersed with the current on for 45 sec. It is removed rapidly and placed in a mild acetic acid bath for thorough rinsing to remove any accumulated sludge, then rinsed in tap water



and dried. The mild acetic rinse consists of 2 to 4 ml. of glacial acetic acid in about 50 ml. of tap water. To polish, about 12 to 18 volts d.c. is used, drawing current within the range 0.02 to 0.5 amperes, the variation depending mainly on the area of specimen immersed. The sample should be agitated during the entire time of immersion.

This procedure should produce an excellent surface for observation by polarized light and often by bright light. It tends to polish some phases and grains of certain orientation preferentially. In some samples this effect may become exaggerated, causing too much "relief" polish, particularly for bright light. Carbides can always be well preserved and polished, unless cracked.

All electropolishing techniques lack exact reproducibility from specimen to specimen. This one has a very narrow working range of current, which must be determined for each sample by trial and error. If the resulting surface has any of the usual undesirable effects of partial polishing, the sample should be immersed for another 30 to 45 sec. If this does not suffice, the sample should be repolished on emery paper and then electrolytically with a slight variation in current.

The condition of the metal has much to do with polishing behavior. Worked structures are difficult to reveal clearly. Cast structures and recrystallized structures produce excellent results. The accompanying micrographs are from samples prepared by the methods described here; none was chemically etched after electropolishing.

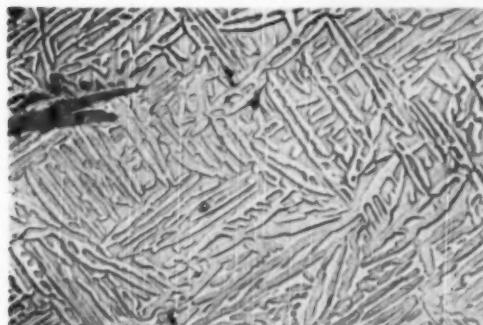


Fig. 5 — Zirconium-Uranium Alloy Containing 15.85% Uranium. Brine quenched after 100 hr. at 1110° F. Carbide appears at upper left as darker gray mass with black voids. Bright light; 250×

Critical Point

By The Editor

White Man's Medicine for Red Man

AMERICAN ORDNANCE ASSOCIATION holds its annual meeting, every three or four years, at Aberdeen Proving Ground, where Army Ordnance officers and men demonstrate the latest guns, ammunition and transport developed for the services, and a breathless show it is indeed. Most notable of the obvious improvements since the Editor's last visit is the waterproofing of the electrical system on all automotive vehicles; a jeep, for example, can ford any creek limited in depth only by the elevation of the driver's nose and the length of the engine's air intake and exhaust chimneys; a standard Patton tank, wallowing through a water hole so deep that only the turret appears, comes out spouting bilge water like a whale, all the time its gun trained on the target by gyro control. Tanks and heavy transport generally are much faster and negotiate almost impassable ground, cross country, rough and swampy. "Power packages" (including 750-hp. engines, trans-

missions and gear-shifting servomechanisms) are replaceable in the field in 20 min. Armored troop carriers accompany the leading tanks in an attacking battalion; like the trick autos in the circus, they disgorge 24 fully equipped infantrymen. Muzzle velocity of projectiles is greater, which means better ability to pierce armor. Weight is progressively saved in all rifles, howitzers and mortars, big and little, by generous use of higher strength steel, welded components rather than castings, and parts made of aluminum, magnesium and titanium. Many of them can now be air-borne and parachuted. Then, too, there are the unconventional recoil-less rifles, bazookas and rocket launchers — much lighter — some lighter indeed than the round of ammunition, and demountable into subassemblies carried by one man. . . . Fire power is greater and greater. Twenty-four rockets from a launcher within a minute are impressive enough, but a burst of tracer bullets from the six machine guns in the nose of a jet fighter is really hair raising — 120 a sec. (repeat second!). Even though the plane is on-target but an instant, it is hard to see how anything could fly through such a spray of lead and yet survive. . . . In the afternoon of this memorable day a mock battle demonstrated how this equipment was used in action. A low hill some 3000 yards away was attacked. It was defended by mythical troops; a half dozen remote controlled tanks and many concealed machine guns and pill boxes heightened the illusion. The area was worked

over pretty thoroughly by field artillery, fighters and bombers, and it is hard to see how many humans could have survived, but the enemy tanks then had to be taken care of, and the pill boxes and fox holes cleaned out (some by flame throwers — a nice, civilized gadget if there ever was one!) before the infantry commander radioed "Mission accomplished". . . . Some Red Korean equipment was trundled past; pretty poor stuff. However, inquiry about the numerous World War II Soviet artillery and tanks on exhibit left the impression that they were stripped of frills, rather rough and ready, evidently made by none-too-skilled workmen, but quite effective weapons nevertheless. ☐



Equipment for the Arctic or the Stratosphere Requires Non-freezing Lubricants and Shock Resisting Metals (Metals With Very Low Transition Temperatures). Photo by U. S. Army

A New Anodic-Film Method for Studying Orientation in Aluminum

IN AN EARLIER ARTICLE, in *Metal Progress* for March 1948, the authors described a method of surface preparation which revealed, at least qualitatively, the orientation of grains in aluminum. Subsequent improvements in technique may be of interest. This paper will report on the following: (a) an electrolyte and technique which give satisfactory results in a shorter time, (b) the extended use of striations as a help to observe changes in orientation, (c) the application of the method for macro-etching, and (d) the application of the method for analysis of flow in plastic deformation and for the study of recrystallization.

Technique—The anodizing electrolyte is mixed in the following proportions:

Orthophosphoric acid (85%)	808 ml.
Diethylene glycol monoethyl ether (Carbitol)	1660 ml.
Hydrofluoric acid (48%)	320 ml.
Boric acid (anhydrous)	128 g.
Oxalic acid (crystals)	72 g.
Water (distilled)	1012 ml.

The ingredients are mixed into the tank and stirred until all are in solution.

The container for anodizing must have chemical resistance and also high thermal conduction so as to transfer heat rapidly from electrolyte to thermostatically controlled jacket. An exploded view of the set-up is given in Fig. 1.

The degree of flatness and polish of the sample is governed by the precision required. Often flattening or polishing is unnecessary. In any event the surface should be clean before its immersion in the electrolyte.

The agitation is controlled in such a way as to have a gentle flow past the sample and yet maintain sufficient flow between tank and central portion of electrolyte to insure temperature control within the limits specified.

Current is derived from a d-c. generator the output voltage of which is so regulated as to procure the desired current density. Normally, less than 40 volts is required; however, if it is desired to smooth out the surface first and to remove a particularly tough oxide skin before anodizing, as high as 70 volts may be required.

The following procedure, at a temperature of $35^{\circ} \pm 1^{\circ}$ C., will be found to give a fairly high birefringence combined with clear striations:

1. Step up the current density to approximately 5 amp. per sq.in. for approximately 30 sec.
2. Then drop the voltage until the current density is $\frac{1}{2}$ amp. per sq.in. and maintain at this level for $1\frac{1}{4}$ min.

3. Remove sample from electrolyte and transfer quickly to cool water. Hot water should not be used for washing and rinsing. Once rinsing is complete, in about 1 min., shake off excess water and dry in a gentle flow of air.

If it is desired to avoid heating of the sample, which may result from Step 1, the voltage should be set at around 30 so as to reach a stable current of approximately 250 milliamp. per sq.in., which is held constant for 5 min. or more, depending on the depth of effect desired.

The procedure outlined above is to give a definite depth of coating and clear striations with

By André Hone
Formerly Head, Physical Metallurgy Division
and E. C. Pearson
Chief Metallographer
Aluminium Laboratories Limited
Kingston, Ontario, Canada

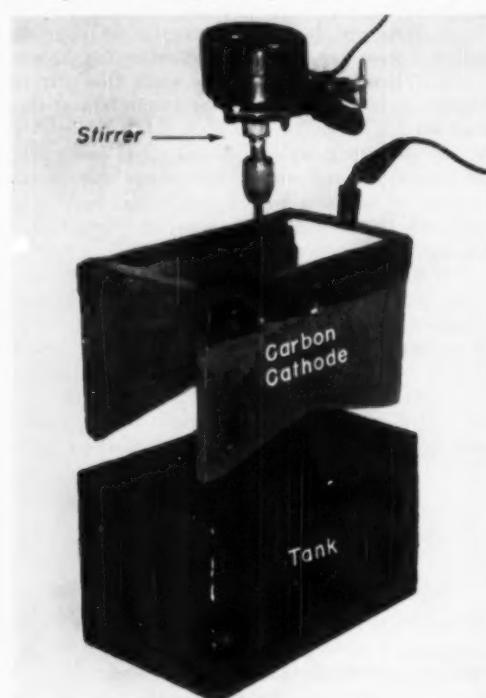
super-purity and commercial purity aluminum. Slight variations of time, current density, and temperature of electrolyte may be necessary with variations of alloy and metallurgical condition.

Applications to Reveal Grain Size

Since the birefringence and direction of striations of the anodic film produced according to the method described above depend on the orientation of the substrate, a very useful application is the revealing of grain size for visual or low-power examination. In Fig. 2 is shown a piece of casting of commercial purity metal which was "macro-etched" as described. Some other alloys have been found to respond quite satisfactorily.

Even very fine grain that is difficult, if not impossible, to reveal by the usual macro-etches may be seen clearly at the low magnifications used for macro studies.

Fig. 1 — Exploded View of Electrolyte Container. Tank itself is made of aluminum sheet, 0.032 in. thick. Cathode is graphite; holes and peculiar shape are to facilitate movement of electrolyte from tank wall to central portion. Chemical protection is afforded by "Nukemite No. 35"



Applications to Plastic Deformation

The gradual change of orientation in a deformed structure may be readily followed by the change in interference colors and by the change of direction of the striations. The manner in which plastic deformation distorts the structure is shown in Fig. 3, 4 and 5.

In Fig. 3 is shown a piece of super-purity aluminum sheet with 0.11% silicon added which was given a reduction of 75% and subsequently annealed for 30 min. at 600° F. Only partial recrystallization has occurred. The parts that have remained unrecrystallized still show the



Fig. 2 — Grain Size in a 4x4-In. Area of Casting of Commercial Purity Aluminum

changes of orientation within one grain caused by plastic deformation.

Figure 4 shows a similar piece of metal at a higher magnification to reveal the detail of the banded grain shown in Fig. 3. In this specimen parallel portions of the grain have rotated in a manner suggestive of twinning.

In Fig. 5 is shown another similar piece of cold worked super-purity metal exhibiting two other types of deformation occurring within one grain. In one type, where the striations are straight, apparently only slip has taken place, with little or no relative rotation from region to region of the same grain. In the other type, deformation has taken place with some rotation. It should be noticed that some grains and portions of some grains receive much more deformation than others if the amount of rotation is taken as a criterion of the amount of deformation. The additional information given by a color micrograph can be

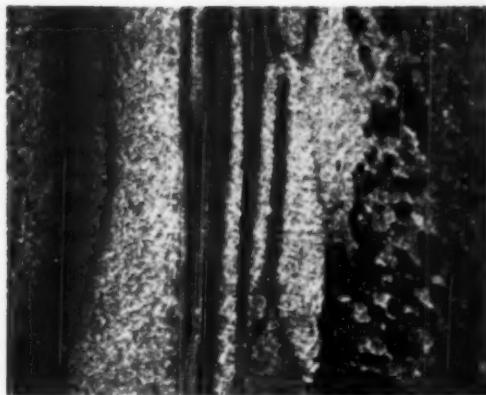


Fig. 3 — Partially Recrystallized Super-Purity Aluminum Sheet With 0.11% Silicon Added. In some regions a cold worked structure still prevails, whereas in other regions recrystallization has started. Of particular interest are the parallel bands in a single deformed grain and the similarity of orientation of a group of new recrystallized grains in a single grain. 100 \times

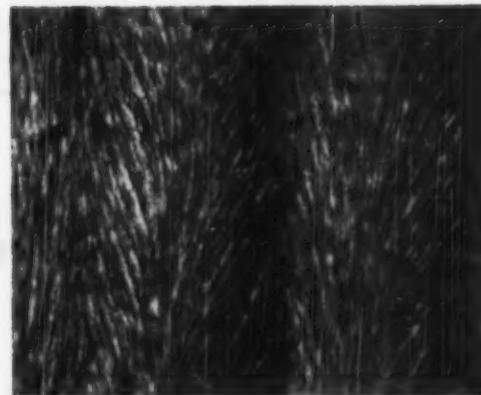


Fig. 4 — Detail (at a Magnification of 500 Diameters) of Parallel Bands in Middle of Field of Fig. 3. From the striations it may be seen that adjacent bands have widely different orientations and that within one band and near the band boundaries there is a gradual change of orientation. Parallel portions of the grain have rotated in a manner suggestive of twinning

judged by comparison of the black and white rendition, Fig. 5, with its color reproduction on the front cover.

Applications for the Study of Recrystallization

By the study of orientations and deformations some light may be shed on the structural changes that take place when a deformed piece of metal is subjected to a thermal treatment for purposes of softening. As an example of the type of information that is obtainable, several features may be analyzed from the structure shown in Fig. 3. The field referred to is the region where recrystallization has started, toward the right-hand side. From it may be deduced:

1. Recrystallization does not occur homogeneously throughout. Some regions of a piece will recrystallize partly, if not wholly, before others.
2. Recrystallization is often observed to start at preferred locations such as grain boundaries or near grain boundaries, or in certain parts of one grain that have been subjected to a different

deformation because of the pressure of surrounding grains.

3. At temperatures near 535° F. (the phenomena at other temperatures have not been studied yet) the new grains forming within a uniform region of a single deformed grain take up a common orientation which is different from the orientation of the deformed matrix. This common orientation is strikingly revealed by the original micrograph taken in color, in which all the recrystallized grains show the same color.



Fig. 5 — Cold Worked Super-Purity Aluminum Sheet. The grain on the extreme left has been homogeneously deformed whereas the two others have suffered some torsional flow. 500 \times . Color micrograph of this area is shown on the front cover of this issue of Metal Progress

This article describes the operation of induction furnaces for melting titanium in graphite, the mechanical properties of the as-cast metal and its forging characteristics.

Casting and Forging of Titanium

THE FIRST YEAR of Du Pont's development work on titanium was summarized in *Metal Progress* for February 1949, p. 195. At that time facilities had just been installed for induction melting and casting 100-lb. ingots in graphite. During the last year, the scale of operation has been gradually increased until 650-lb. ingots are now being cast regularly by the same technique. Several thousand pounds of titanium have been melted in the furnace represented in Fig. 1.

Basically, the furnace consists of a graphite melting pot (1) (CS-grade graphite) insulated by carbon black from an exterior silica or transite shell (2). Shell temperatures do not exceed 400° F. and transite is preferred because of mechanical stability and lower cost. A short pouring spout is threaded into the bottom of the melting pot and feeds into a removable graphite liner (3), surrounded by a permanent graphite sleeve (4). The metal pours through the liner into a graphite mold (5) provided with a removable plug (6). The mold is held in place by a mechanical jack (7) to facilitate assembly. The melting crucible is supported by porous carbon blocks (8) which, in turn, are supported on a 1-in. transite plate (9). Threaded hangers (10) from aluminum angles (11) support a graphite mold lid (12). The density of sponge does not permit holding of the entire charge (650 lb.) in the melting crucible, and a hopper (13) equipped with feed rods (14) and sight glasses (15) is employed. Sponge flows from the hopper through a steel tube (16) into a graphite pipe (17). A poke rod (18), centered by a graphite bushing (19), is

necessary for measurements of sponge depth and may be used for clearing the pouring spout. Energy is transmitted to the crucible by a water-cooled copper induction coil (20) powered by a 100-kva., 9600-cycle motor-generator set. Tapping is accomplished by fusion of a titanium plug inserted in the pouring spout. A secondary water-cooled copper coil (22) provides the necessary energy. Temperature measurement, based on optical pyrometry, is made by sighting on the bottom of blind, argon-flushed tubes (21) located in the wall and center of the melting crucible. Argon is introduced to the melting crucible, mold, and hopper (23) and vented (24) through the transite lid (25). Pressure is relieved during casting by an expendable rubber balloon (26).

A typical cycle consumes about 10½ hr. for a 450-lb. ingot, consisting of the following steps:

1. Charge sponge to crucible and hopper.
2. Flush 2 hr. with 8 cu.ft. of argon per hr.
3. Initiate power to the primary coil (20) to 25 kw. for 1 hr., during which time furnace temperature reaches about 1650° F.
4. Boost power input to 40 kw. for next 2 hr.

By **J. Bartlett Sutton and Edwin A. Gee**
Pigments Dept., Newport, Del.
and William B. DeLong
Engineering Research Laboratory, Wilmington, Del.
E. I. du Pont de Nemours & Co.

at which time the charge will have settled to one half its original volume.

5. Initiate hopper feed; charge level is maintained relatively constant by means of poke rod measurements.

6. Add feed intermittently for the next 5½ hr. and regulate power so that the crucible wall temperatures do not become excessive (3140° F. max.).

7. When the entire charge is molten, energize the tapping coil and drop the melt. If necessary, the poke rod is used for clearing the spout.

8. After cooling 6 to 8 hr., open apparatus and discharge ingot.

Pertinent data on a 450-lb. melt are:

Total cycle	10½ hr.
Pouring temperature	3150° F.
Energy input	274.1 kw-hr.
Energy per pound	0.609 kw-hr. per lb.

Shrinkage on solidification is about ½-in. on the diameter of a 16-in. ingot, allowing for easy removal from the mold. Surface is good, as was illustrated in Fig. 1 on p. 190 of *Metal Progress* for August 1950.

In contrast to what occurs to many metals, titanium ingots do not pipe, probably due to the presence of hydrogen, which approximates 0.006% in both sponge and ingot. In fact, a negative pipe or top bulge results.

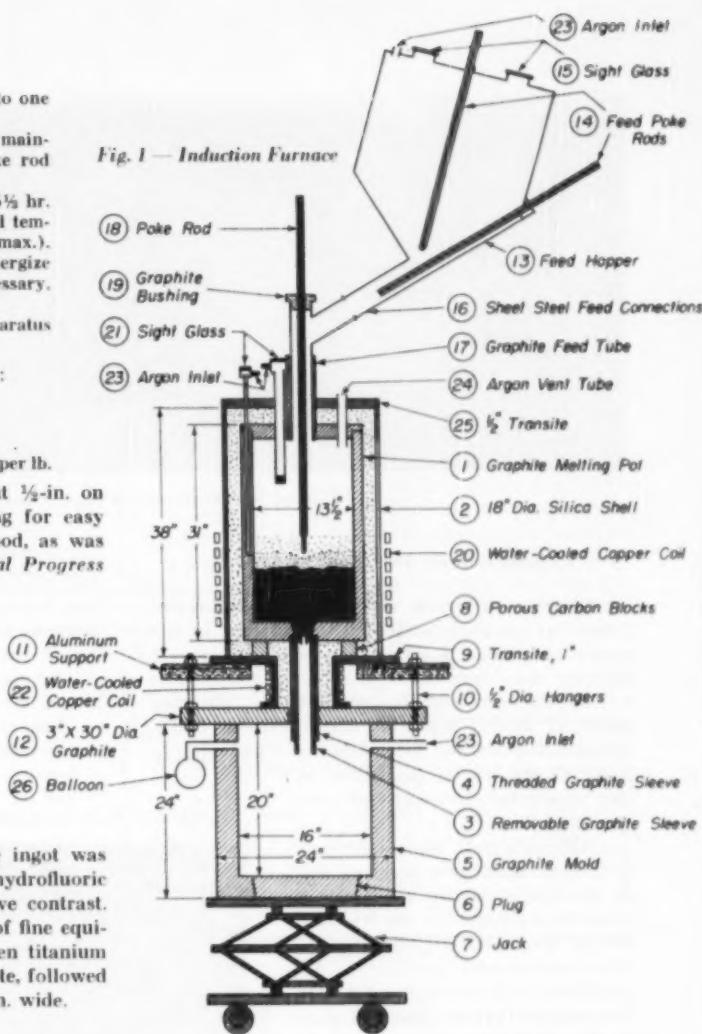
The hydrogen may collect in small pockets, forming an envelope not unlike rimmed steel; this phenomenon is shown in Fig. 2. The ingot was polished and etched with dilute nitric-hydrofluoric acid and india ink was used to improve contrast. The macrostructure shows a thin skin of fine equiaxed grains which formed as the molten titanium was chilled by the relatively cold graphite, followed by an envelope of blowholes, 1½ to 2 in. wide.



Fig. 2 — Section Through a "Rimmed" Titanium Ingot, 8 In. Across Top

Columnar structures can also be produced at lower cooling rates, as shown by the 400-lb. ingot in Fig. 3, p. 718. This solidification condition apparently minimizes blowholes. A fine equiaxed

Fig. 1 — Induction Furnace



exterior is noted, followed by columnar grains exhibiting directional solidification; medium-sized equiaxed grains are shown in the ingot center.

Ingots produced by induction melting of sponge titanium usually contain 0.4 to 0.8% carbon and 0.02 to 0.06% nitrogen. Brinell hardness is in the range from 200 to 250.

Alloys are easily prepared in this type of furnace, and ingots containing as much as 35% aluminum, chromium, iron, manganese, and nickel, with the remainder titanium, have been cast without difficulty. Because the entire charge is molten, there is no abnormal tendency for segregation or "layering" of the alloying constituents. Pouring temperatures are usually lower, and carbon pick-up can be held to 0.5% or less in some alloys.



Fig. 3 — Typical Macrostructure of Ingot Measuring 13 In. Across

Properties of As-Cast Titanium

Contrary to many reports, good mechanical properties can be obtained with titanium in the as-cast condition. A series of specimens of several different sizes were cut from different positions in a 7-in. diameter, 100-lb. ingot of the following analysis: 98.48% titanium, 0.98% carbon, 0.06% nitrogen, 0.05% iron. Table I, at top of the opposite page, shows tensile properties at two positions for each of two specimen sizes.

Although there was a difference in fracture grain size, probably due to the variation in solidification conditions between the top and bottom specimens, the tensile properties were roughly equivalent. All specimens exhibited the familiar "orange peel" surface along the gage length, indicating homogeneity of the material and lack of local defects.

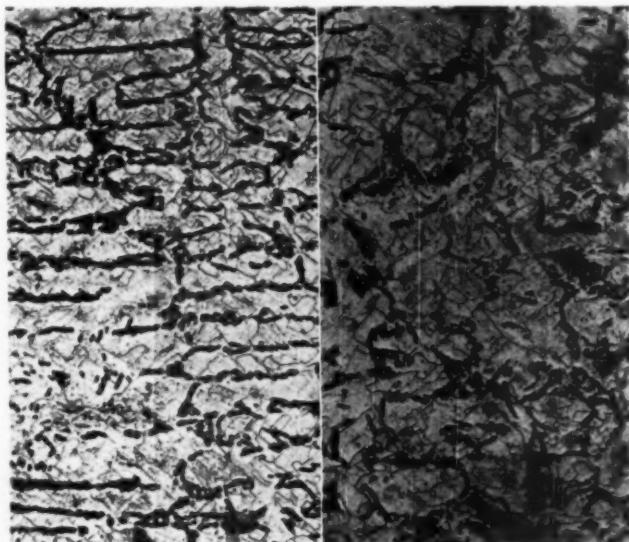
Oriented dendrites were observed in these specimens and fracture tended to take place parallel to the dendritic trunks. Even with such unfavorable orientation, 7 to 8% elongation in 2 in. was achieved. The association of carbide chains with transformed beta dendrites is clearly demonstrated in Fig. 4 at right.

The typical top-bulged surface represents an interesting ingot structure. Oriented dendrites perpendicular to the top surface indi-

cate that freezing occurred prior to complete center solidification (top of Fig. 3), and it is postulated that rejection of hydrogen in the molten center displaces the top upward. [EDITOR'S NOTE: Swelling of cast slabs of copper and its alloys is such an abstruse phenomenon that the real reason may be obscured.]

Other cast alloys prepared by arc melting have shown elongations of 15 to 20% in 2 in.

Fig. 4 — Fracture Surfaces of 0.250-In. Tensile Bar, 100×



Parallel to fracture directionality

Perpendicular to fracture directionality (end view of dendrites)

Table I—Tensile Properties of As-Cast Titanium

POSITION	SPECIMEN DIAMETER	TENSILE STRENGTH	0.2% YIELD STRENGTH	ELONG.	R. A.
Top, radial	0.505 in.	92,000 psi.	81,500 psi.	7.0%	9.5%
Top, radial	0.250	96,800	87,900	7.0	7.1
Bottom, radial	0.505	94,400	83,000	7.5	9.0
Bottom, radial	0.250	98,400	88,000	8.0	7.0

Forging

As was reported by J. Maltz and V. DePierre of U. S. Naval Gun Factory in *Metal Progress* for August, the forging of commercial titanium containing 0.78% carbon offers no special difficulty; the metal flows more readily than mild steel at the same temperature. These experimenters used the ordinary heating and forging techniques found in drop forging shops making steel parts. Their work included hammer forging between flat dies, hot rolling in a plate mill, and drop forging into small levers.

Commercially pure titanium containing about 0.7% C flows freely in the temperature range 1800 to 1500° F.; higher temperatures do not increase forgeability much, as can be seen from the data in Table II, developed in cooperation with the Wyman-Gordon Co. The constancy of the delivered blow in these tests depended on the operator's skill and was not mechanically controlled.

After forging, hardness transverses were made along the center line of a slice cut from each disk. All samples showed a uniform hardness

Table II—Effect of Forging Temperature

TEMPERATURE	FORGING BLOWS*	
	RUN A	RUN B
1600° F.	45	36
1700	21	22
1800	18	19
1900	16	17
2000	15	16
2100	17	15

*Number of blows to reach a constant deformation.

of about 240 Vickers, excepting the sample forged at 1600° F., which tested 273 Vickers, probably due to cold work. The 1600° sample also exhibited a higher tensile strength, as can be seen in Table III.

Microhardness surveys showed a maximum depth of hardening of 0.020 in. on the piece forged at 2100° F. This hardened layer was found on the portion of the disk that had rested on the cold anvil during forging and probably represented the maximum depth of hardness penetration during heating. It was found that the hardened zone or layer penetrated to an extremely shallow depth on the upper surface of these disks, indicating that the hardened layer probably broke off during forging. No hardened layer was found on the piece forged at 1600° F.

Table III—Mechanical Tests on Upset Forgings

FORGING TEMPERATURE	0.2% YIELD STRENGTH	TENSILE STRENGTH	ELONGATION	VICKERS HARDNESS*
1600° F.	106,000	112,000	10%	273
1700	92,000	100,000	8	237
1800	86,000	99,000	10	240
1900	85,000	96,000	12	239
2000	85,000	98,000	17	230
2100	81,000	95,000	16	241

*Average across sample.

Voids in titanium appear to be satisfactorily welded by simple forging. Forging tests on an ingot containing numerous voids sealed completely after 50 to 80% reduction in cross section area. This is shown by Fig. 5, illustrating the microstructure after 80% reduction. No holes or lines are observed which would be indicative of simple flattening of the voids without welding, and tensile tests on the forgings showed normal values. The fact that welding is obtained between titanium sheets pack-rolled at 1450° F. is further evidence for this conclusion.

Typical cast and forged structures for a titanium ingot containing about 0.8% carbon are shown in Fig. 6. The dendritic carbide pattern is readily apparent in the as-cast metal. On forging, the dendritic structure is replaced by a random distribution of rather small rounded carbides.



Fig. 5—Cross Section of Forging After 80% Reduction. Unetched; 50 X

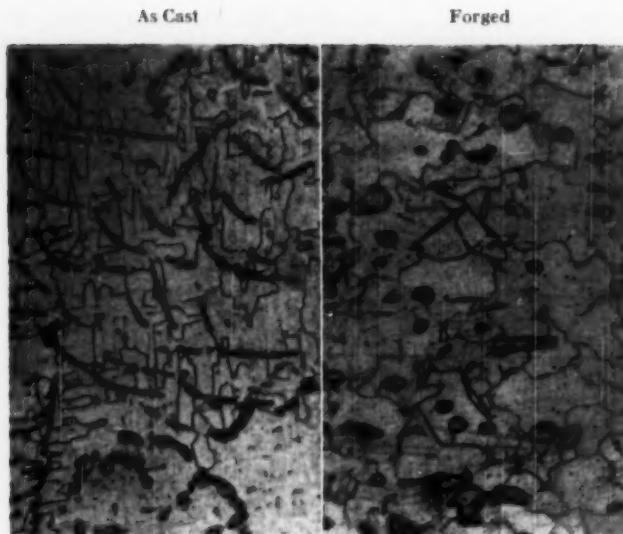


Fig. 6 — Carbides in Titanium Containing 0.8% Carbon. 250 \times

Similar results are obtained with more complex alloys. The as-cast and forged structures of a 3% Al, 5% Cr, 0.5% C alloy are shown in Fig. 7. Again dendritic carbides are well broken up on forging. The dark-etching constituent, which is acicular alpha phase, seems to be concentrated around the carbide particles and grain boundaries, indicating that the beta-to-alpha transformation started at these regions as the forging cooled.

Hardness

The hardness of titanium and its alloys can be applied in many cases as a rough measure of strength and ductility. Since all of the conventional hardness scales are being used, several series of comparative measurements have been made relating the Brinell, Vickers, and Rockwell A and C scales. These data, based on numerous measurements on over 50 samples of forged and rolled material, are plotted in four drawings on data sheet on p. 720-B. Another graph at the center of the sheet shows the relation between tensile strength and hardness for a series of rolled

strip specimens of iodide, arc-melted, induction-melted and titanium alloy. It is obvious in this graph that the tensile strength of iodide strip and annealed strip is proportional to the Vickers hardness number (10-kg. load). Strength of forged and air cooled forgings is also proportional to hardness, but the ratio is somewhat larger.

Conclusions

A commercially feasible method of casting titanium ingots up to 650 lb. has been developed. Such ingots are homogeneous and contain as the primary impurity about 0.4 to 0.8% carbon. Complex alloys have been prepared without any apparent segregation.

The structure of titanium ingots is sensitive to pouring temperature and rate of solidification. Porosity which occurs in some ingots is apparently eliminated by welding during forging. As-cast titanium shows appreciable ductility.

Conversion curves relating various hardness scales for titanium have been prepared.

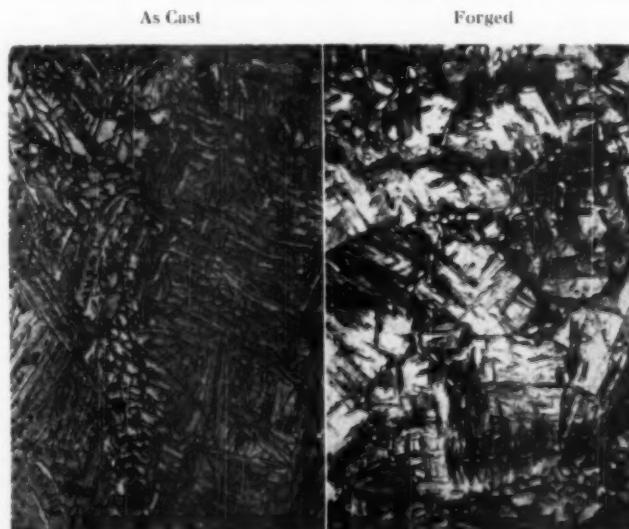


Fig. 7 — Carbides in Titanium Alloy Containing 3% Aluminum, 5% Chromium, 0.5% Carbon. Dendritic carbides are well broken up on forging. 250 \times

NISILOY

A POWERFUL, POSITIVE INOCULANT

Cuts Final Cost of Gray Iron Castings

by improving

MACHINABILITY, GRAIN STRUCTURE, UNIFORMITY

BENEFITS TO FOUNDRYMEN

Reduces Rejects—Used for structure control of cast iron, Nisiloy helps your foundry meet daily schedules for uniform lots of machinable gray iron castings.

Promotes Sound Castings—Diffusing rapidly throughout the melt, Nisiloy promotes a dense, close-grained product.

Curbs Breakage—Even where section thickness varies sharply, Nisiloy serves to eliminate chilled edges and surfaces, thus affording a tougher cast iron that resists breakage in shop handling.

No Scrap Problem—Containing only elements that dissolve freely in iron, Nisiloy permits remelting sprues and gates in any successive melt without risk of adding chill-forming elements.

Fewer Base Mixtures—Often a single base mixture may be used in the cupola to which Nisiloy is added in the ladle, with the consequent flexibility of pouring off thin or thick sectioned castings as desired.

For full information about this nickel-silicon alloy, one of the most useful products ever offered for improving machinability and structure of gray iron castings, fill in and mail the coupon below.

BENEFITS TO CASTING USERS

Excellent Machining Qualities—The dense, gray, machinable structure secured with Nisiloy reduces machining time, tool wear, rejects and costs.

Increased Wear-Resistance—The formation and distribution of finely divided random flake graphite accomplished with Nisiloy assures highly improved resistance to wear.

Improved Toughness—Nisiloy acts to eliminate hard, chilled areas...thus, the casting is thoroughly machinable in thin and thick sections alike and less sensitive to breakage in machining operations and general service.

Dependable Pressure-Tightness—The sound, homogeneous structure attained by inoculating with Nisiloy results in dense cast iron that provides substantially improved pressure-tightness.



The International Nickel Company, Inc.
Dept. MP, 67 Wall Street, New York 5, N. Y.

Please send me your booklet entitled:
"NISILOY" for GRAY IRON CASTINGS

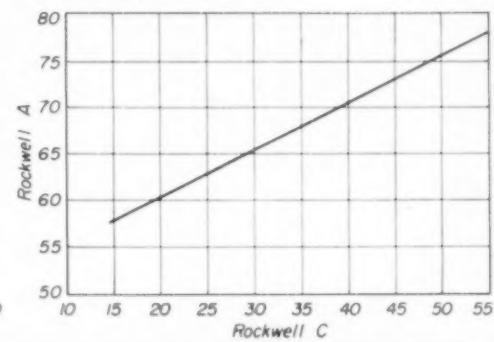
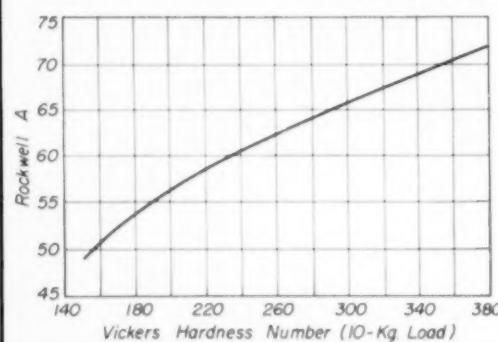
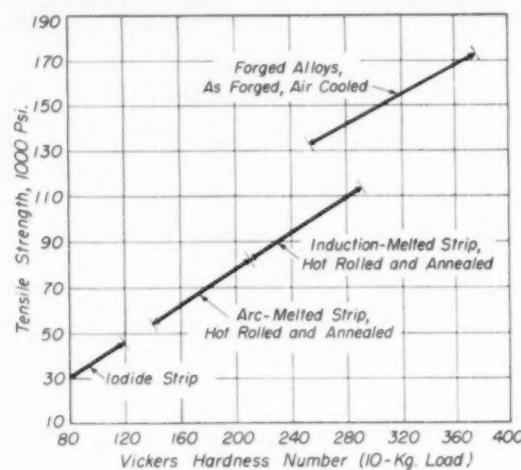
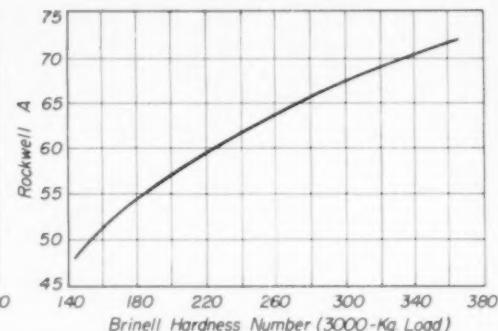
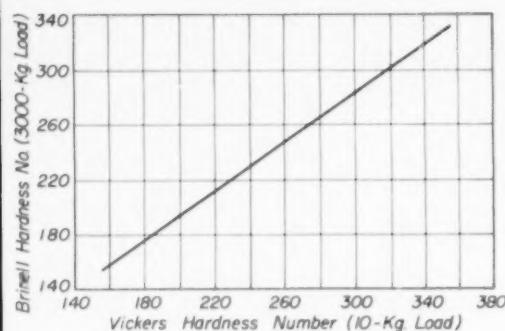
Name.....
Company.....
Address.....
City.....
State.....
Title.....

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK 5, N.Y.

Hardness Conversions for Titanium and the Relation Between Hardness and Tensile Strength

Compiled by J. B. Sutton, E. A. Gee and W. B. DeLong

E. I. duPont de Nemours & Co., Inc.



Tests show New Quench Oil has Intensified Triple Action

● A new accelerated quenching oil has been developed that gives (1) rapid heat removal with faster cooling rate in the hardening range, this results in higher and deeper hardness; (2) slow cooling below the hardening range, thus minimizing distortion; (3) greater stability due to special anti-oxidants, for longer life and bright quenching properties.

To better illustrate the manner in which this triple action quenching oil accomplishes this higher quenching efficiency, it will be well to show the three stages of cooling as observed when steel is quenched in oil from a red heat. These stages are:

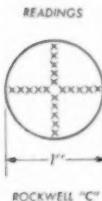
- Formation of a vapor film at the steel surface; cooling is accomplished by conduction and radiation through this vapor film and is relatively slow.
- Direct contact of the oil with the metal surfaces, causing a boiling action which continually dissipates the vapor film formed and results in rapid cooling.
- After the metal has been cooled to the boiling point of oil, vapor is no longer formed; cooling is by conduction and convection, and the metal slowly cools to the temperature of the oil.

It is apparent that any improvement in the cooling power of oil in stages A and B would be most desirable. This can be compared to the brine quench which is used instead of water. Brine has a wetting action that completes the quench faster than fresh water, which "takes hold" only in spots, causing non-uniformity. Salt brine solutions provide deeper and more uniform hardnesses. This results in deeper and more even hardnesses. It seems logical to attempt to do this same thing with oil. The mineral intensifiers added to this Triple A Quenching Oil act in this manner.

Practical Application of Quench Curves to Hardening Steel

The improvement of oils so as to effect this desired change in the cooling characteristics has been attempted in the past by blending mineral oil with animal oils, but the product was prone to become rancid, or to decompose on contact with hot steel. These blends were also unsatisfactory as quenching mediums for steel treated in certain types of salt baths.

Developed in the Research Laboratory of the Park



READINGS
STEEL: S.A.E. 1045 1" ϕ x 2"
TREATMENT: 1550° F. IN NEUTRAL SALT
QUENCH IN OIL AT 75° F.
HARDNESS: ROCKWELL "C" READINGS
ACROSS INNER SURFACES
OF SECTIONED SAMPLES

Chemical Co., the Park Triple A Quench Oil, a blend of specially refined mineral oils, cools steel faster in the upper temperature range by shortening the duration of vapor stage (A) and intensifying the action of boiling stage (B). Heat removal in stage (C) is slow and uniform. Thus, the best surface hardness and depth of hardness penetration are achieved with no danger of cracking or distortion.

Extremely stable, this new accelerated quenching oil may be used as a quench from any heat treating medium without fear of rancidity, oil breakdown, or change in quenching efficiency. Further, Park Triple A Oil is especially suitable for obtaining the maximum uniform oil-quenched hardenability from low and medium alloy steels.

Results of the improvement are shown in chart below showing actual hardnesses in quenched pieces. There is a 16% surface hardness increase with Park Triple A Oil over a good grade of straight mineral oil. The effect would be greater when comparing it with some of the poorer grades of oil used for quenching. Center hardnesses of the one-inch diameter piece are up 14%. Lighter sections would show even more increases.

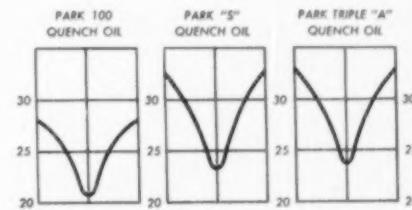
Bright Quenching and Stability

A very crucial and costly problem in the carbo-nitriding process has been the cleanliness of work after oil quenching. Oils which deteriorate rapidly or were originally unsuitable leave a sooty carbonaceous film on the surface of the work. This presents a difficult cleaning problem when followed by a plating or welding operation.

This difficulty, when not the fault of the furnace atmosphere, can be corrected by the use of Park Triple A Quench Oil.

Through the use of anti-oxidant additives and mineral intensifier it has been possible to prolong the bright quenching properties of good clean oil. Underwood Oxidation experiments have proven Park Triple A Quench Oil to have exceptional stability and long life.

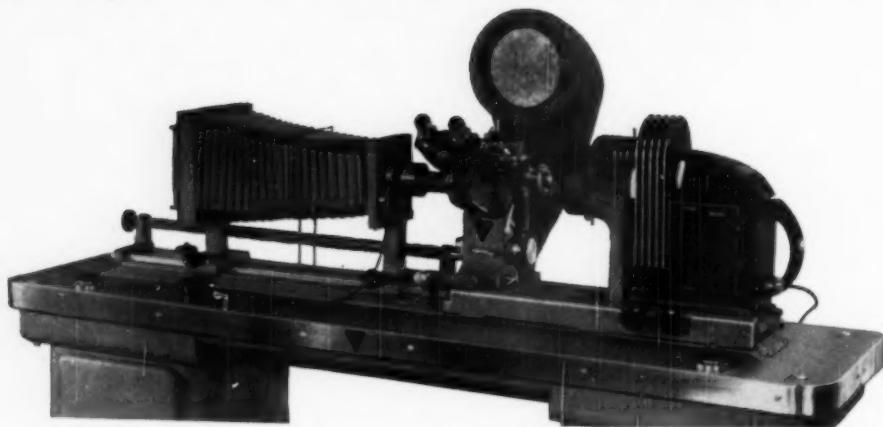
A Bulletin, #F8, was prepared on Park's Triple A Quench Oil. It gives you a complete description of this oil with cooling curves, production data and photographs. Write Park Chemical Co., 8074 Military Ave., Detroit 4, Mich.



Transverse hardness Re taken on 1" round SAE 1045 steel two inches long. Quench from Park's Nu-Sal neutral salt at 1550° F. into three types of quench oil, Park's No. 100 Oil (straight paraffin), Park's "S" Oil (compound with animal oil), Park's Triple A Oil. Oil temperatures 75° F.

NEW!

Bausch & Lomb *Balphot* METALLOGRAPH



ALL NEW DESIGN! NEW SPEED and CONVENIENCE!
Plus the
NEW MAGNA-VIEWER!

You asked for this instrument! You helped specify its new convenience features. Exclusive features like these: *Straight-Line Observation*—Magna-Viewer, stage, microscope and eyepiece are all in one line, for easy direct observation; *Centralized Controls*—ALL controls are within easy sight and reach of seated operator; *New Fine Adjustment Mechanism*—Graduated knob measures travel . . . smooth, backlash-free motion; *Improved Heavy-Duty Mechanical Stage* built on ball bearing rotatable support. *Elevating Device* (patent applied for) eliminates coarse adjustment—permits quick inter-change of objectives, retaining focus! *Visual Illuminator* is built-in. *Improved Filter System and Heat Absorbing System*—Swing-out filter holders . . . New heat-absorbing glass replaces the water cell; *Solid Cast Optical Bed*—Pro-

vides sturdy, shock-absorbing support for camera, microscope and light source with greatly increased image stability. PLUS the *New Magna-Viewer*—Projects bright, magnified screen images; ideal for prolonged observation, such as grain-size work and dirt counts . . . eliminates fatigue, results in better, faster work.

This is it . . . the metallograph which gives you the economy of limited capacity instruments with many performance advantages of the highest-priced metallographs . . . at an initial cost in the medium range. This is the instrument you want for all general metallography.

Write for complete information to Bausch & Lomb Optical Co., 638-W St. Paul St., Rochester 2, N. Y.



Bausch & Lomb *Balphot* METALLOGRAPH

*In the Campbell Memorial Lecture, Mr. Smith vivaciously draws a parallel between the impediments that all but discouraged such early ironmakers as Dud Dudley and the regulatory measures in today's socialistic and welfare states. Acknowledging that the blast furnace is not an efficient machine, he then discusses several methods for improvement. Metal Progress is able to use only about 15% of the entire text, which will be published complete in **Transactions**.*

Iron Smelting Problems

I MAKE A DIRECT REQUEST, as a friend of the blast furnace men, that we get acquainted with at least some of their problems, which are by no means limited to technical difficulties. In considering some aspects of the modern problem in the background of medieval times, we find that Biringuccio in 1540 wrote chapters on iron smelting which are better records of his day than exist to describe our early American furnaces. With but slight modification the chapter on iron ore could describe today's situation. The business is bigger but the problems have not changed.

Our own records are far from complete. It may be that present-day operators of blast furnaces only carry on an age-old tradition that iron is important, skill paramount, and records incidental.

Table I—Commercial Iron Ore Reserves in U. S. (1950)

REGION	AVERAGE GRADE	GROSS TONS
Northeastern	60% Fe	1,600,000,000
Southeastern	35%	1,100,000,000
Lake Superior	51.5%	1,600,000,000
Western	50%	800,000,000

In any process which depends upon the skill of the operator and where the moves are carried out on a trial basis, the record is always of secondary interest. There remains the fact that our science has not provided the blast furnace man with a road map.

Iron Ore—The byproduct coke oven, the Mesabi ore discovery, the use of basic openhearth steelmaking, and the Duquesne blast furnace com-

bined to increase the steelmaking capacity. Steel plants were built near consuming markets without regard to adequate transportation of ore and coal, and now, in less than two generations, we find the blast furnace man wondering what ore he will be using next season.

It is impossible for me to agree that we are nearing the end of blast furnace ore in North America. (See Tables I and II, from data of U. S. Geological Survey.) The lowest iron content ore that I have observed in commercial blast furnace was used at Scunthorpe, England, during 1942. The actual local ore with 16% iron was combined with comparatively rich Corby ore which had 29% iron. These excellent furnaces with outstanding performance records are leading the way in carbon lining for big furnaces. If this country ever gets humble enough to quit crying and go to work we need not use any 16% iron content for several hundreds of years. The coke blast furnace is a flexible tool in industry. It is effective—not necessarily efficient. What it can actually use has never been clearly established.

Linings—Blast furnace firebricks, the resultant of some hundred years of trial and error, represent the blending of different clays. The usual combination consists of a clay with good refractory properties and indifferent bonding qualities mixed with another clay that may have mediocre refractory properties but excellent bonding ability. The

By Earle C. Smith
Chief Metallurgist
Republic Steel Corp., Cleveland

Table II — Active Foreign Iron Ore Interests

COUNTRY	GRADE	APPROXIMATE RESERVES	INTERESTED COMPANY
Chile	55%	105,000,000	Bethlehem
Liberia	66%	15,000,000	Republic
Venezuela	42%	110,000,000	
Cerro Bolivar	High	1,000,000,000	U. S. Steel
El Pao	60%	60,000,000	Bethlehem
Canada			
Labrador	60%	400,000,000	Iron Ore Co. of Canada
Steep Rock	55%	280,000,000	U. S. and Inland
Michipicoten	35%	100,000,000	Jones & Laughlin

whole business, the exact particle size of each clay, the amount of ingredients, the molding, drying, burning, inspection, and shipping, is a mixture of art, science, skill and commerce.

Since a blast furnace hearth is expected to be in service many years, special masons, moving from company to company, lay the brick. The furnace operator uses the best judgment and skill available in blowing in the furnace. In spite of all known precautions we have significant variations in the same furnace with different linings from the same brick company, with everything as nearly identical as customary testing could determine. In recent years a lining in a furnace lasted one week. Another furnace, after a full campaign, still had a hearth so nearly perfect that the salamander iron was less than 100 tons. That is the blast furnace man's major problem in its nasty aspects. He is expected to get at least 2,000,000 tons of iron or more production from a hearth.

The brick that failed prematurely showed upon examination that internal fissuring in the brick permitted iron to penetrate the fissures. Molten iron is not a very sturdy bond for the flint clay particles which make up the real body of the brick. Such failures, although very rare, explain in part why the European blast furnace men risked carbon blocks in their hearths and the reason behind the present experiment with carbon hearths in the United States. The Thomas basic bessemer process of Europe requires an iron, high (2%) in phosphorus, that is more fluid than the lower phosphorus irons we use in American steel-making. Hearth breakouts were more of a problem in blast furnaces making such fluid iron.

There have been several quite serious failures with carbon hearths in the United States and some of these failures have not been adequately explained. Personal observations indicate no problems impossible of solution. The working face of carbon-lined hearths has given little trouble. (Saw cutting marks have been observed on carbon blocks in a hearth after making hundreds of thousands of tons of iron.) Trouble has occurred at the iron notch area; wet notch clay and resultant steam destruction are the probable explanation. Damage to the blocks away from the working face

has been explained by oxidation from steam as a probable cause, along with oxidation due to air infiltration. While we provide a tight brick outer shell, and attempt to prevent access of air to the hot carbon, we are more concerned about leaking water near the hearth.

The carbon hearth may have arrived at the proper time. After studying the probable ore supply for future ironmaking in the United States one can anticipate less alumina for the slag systems involved. In at least two recent hearth breakouts the lack of alumina (9 to 10% Al_2O_3 slags) caused the furnace to slag the lining to satisfy the need for alumina. As in many other industrial moves, the accessory protection of the non-slagging carbon block may well be more important than the primary saving visioned at the time of installation.

A modern turboblower for a blast furnace may be said to be able to deliver 100,000 cu.ft. of air per min. at 30 to 35-psi. pressure. Normal operation requires a blast that exceeds the approximate 18-psi. pressure drop through the stack by enough to force the gas out of the furnace through

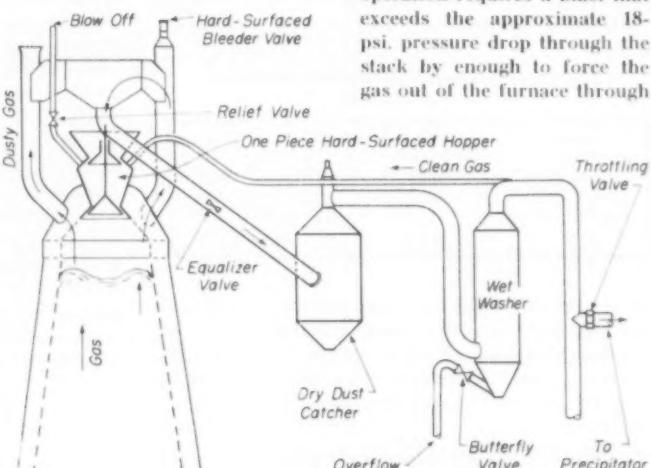


Fig. 1 — Blast Furnace Alterations for Pressure Operation

the cleaning and into the gas system. Pressure at the top of the furnace is about 2 psi.; furnaces that are being pushed rarely exceed 4 psi. at the top. There are many operating reasons why this pressure has not been exceeded, but the most important is excessive dust loss.

Pressure Operation

High-pressure operation of blast furnaces was developed under the invention of Julian Avery. In 1938 Avery, then with A. D. Little Co., suggested that pressure operation at one or two atmospheres above normal be achieved by controlling the outflow of gas. His invention concerned the automatic throttle valve at the outlet (see Fig. 1). As no furnace was equipped to carry such pressure, the demonstration awaited the war with its shortage of iron which justified the trial.

The Defense Plant Corp. furnace, adjacent to the Cleveland plant of Republic Steel Corp., was operated by our blast furnace group under J. H. Slater, whose untimely death before this development was fairly started deprived the industry of one of this generation's most capable men. The general foreman of this furnace, Walter Montgomery, has been with this operation since the start.

Cost calculations indicated that the furnace could be pushed with Lake ore until the dust loss exceeded 350 lb. of dust per net ton of iron. Such an operation did not require any change in the structure. Top pressure operation required turbo-blowers in series and regulator valves in the gas main behind the washer.

Although such early operation under the observation of War Metallurgy Committee indicated an excellent normal operating stack, pressure operations brought on a series of problems. Numerous gas leaks caused damage by grit blasting. Gas washer seals were inadequate. The new pressure regulating device was not well understood. When the furnace was finally able to operate, it was found that dust loss was very small—also that the furnace could handle the additional wind without getting rough in operation.

Joe Slater and Walter Montgomery, who had



Earle Clement Smith

HIS PERSONAL INTEREST in blast furnaces, he says, "started 50 years ago when I burned a bare foot exploring the mysteries of a cast house in New Castle, Pa." Educated at Ohio State University and by U. S. Army Ordnance, he has been with Republic Steel Corp. or its predecessors since 1919, for 18 years in operating positions and since 1932 as chief metallurgist of the corporation, wherein he exercises his almost encyclopedic knowledge of all phases of steelmaking, plain and alloy.

pushed the furnace during normal operating experiments to establish an upper limit of wind regardless of dust, were satisfied that less than 90,000 cu.ft. per min. of wind could be used with straight Lake ore burden. Mr. Slater's most important criterion of test was simple: "Would the furnace settle down and drive smoothly when higher wind and top pressure were tried?" Blast furnace men are by nature determined people. Before Slater died, he and Montgomery had blown 110,000 cu.ft. of wind per min. with 11-psi. top pressure and had a smooth furnace on straight Lake ore.

The first lining finished its usefulness early in October 1950, and finally the first chapter of its history can be written. We know we can operate for normal periods of time. Republic Steel Corp. will provide additional furnaces as we can afford the equipment cost.

We have behind us the actual operating experience. We have before us many problems, such as better methods of stopping

gas leaks (grit blasting). Bell and hopper wear have been brought under control by equalizing the pressure between the bells with cleaned gas. Lining erosion, always a problem even in a normal furnace, does not seem to be any different in pressure operation.

We have not yet had an opportunity to study some rather interesting problems such as optimum size of limestone, coke, charging sequence, proper top temperature, blast heat for various burdens, the proper type of sinter and even the transportation problems that arise with increased production.

We have not explored the higher top pressures—that is, above 12 psi.—because of limitations of furnace construction. (One instance of faulty welding in a dust catcher top showed up as we increased the pressure.) We will have to feel our way into new methods as we equip more furnaces and develop structures to handle the higher stresses.

Gas Studies

Studies and calculations concerning blast furnace gas have gone hand in hand with furnace development. Sampling has been an outstanding

problem; analysis of the gas is not particularly difficult; interpretation of results is as variable as the schools of furnace operators. The Bureau of Mines' studies of some years ago furnished a mass of well-handled measurements. Interpretation of these data is still a matter of personal opinion. The present interest in gas study is important because of the relative increase in coke cost and operating expense. (Ore and transportation costs have also gone up but not in the same proportion as coke cost.)

Efforts to correlate the known variables for which data are obtained fall far short of the need since they do not include the *reducibility* of the iron ore. It has been known for hundreds of years that limonites, hematites and siderites reduce with less trouble than magnetite. In Biringuccio's time the magnetites were not considered "ore" in that area, even though the Swedish furnaces had solved the problem of reduction of magnetite many years earlier. Dense hematite ores were known to be difficult to reduce unless crushed to small particle size. Reduction studies to arrive at some measure of reducibility have been made in many laboratories. There have been many full-size furnace runs which give gross figures. All these tests are useful to the furnace operator but none permits him to burden his furnace except on an empirical basis. [In his presentation Mr. Smith had many slides showing the different characteristics of the iron oxide in many commercial ores, and the different grain sizes and methods of agglomeration in various pellets and sinters.]

In our studies in Cleveland it has been determined that several hours elapse between significant changes of top gas chemistry and the corresponding changes of analysis of the iron, despite the fact that the British experiments with radon tracers indicate but a few seconds travel time for gas.

Furnace performance changes slowly. Five hours after the gas warning, the iron from the furnace at Cleveland gives confirmation. During that period we can make changes in the operation such as higher blast heat, change of burden. The dramatic way that a water leak of consequence shows, permits repair to be undertaken in minutes. The major burden changes still require hours. Extra coke at the top is seven hours ahead of significant gas changes. Wind rate changes show very quickly because of altered CO/CO_2 ratio. The combination of this work and Walter Montgomery's utilization of the information has produced much more uniform analysis iron. Our best test period was one in which he predicted correctly his cast conditions over 80% of the time and his operating changes hours in advance, thus resulting in many more casts of iron of desired chemistry.

Blast Furnace Comment

In a letter about a year ago from a man who does not think the big blast furnace is anything to be worshipped, he says:

"The blast furnace is not efficient, and under existing circumstances can scarcely be a money maker, provided the bookkeeping is honest. It has but one virtue — size. It is an affliction sent on the industry for reasons not yet understood."

With the comment that the blast furnace is not efficient I can agree but the critic forgets that every day we are willing to give ground technically for effective economic performance. What the writer missed and what the public seems to miss, in my opinion, is this very evident fact. No working unit in any metal industry can match the blast furnace in tons of useful product per unit of time. Talk of substitution is a waste of breath. Studies concerning replacement of iron with other substances within the span of our lives is a waste of time and substance.

What we need, rather, in this country is to provide the transportation facilities to move the ore we know is available. We need some reasonable assurance that coal will be mined to provide the required coke. (The nearly 30,000,000 tons of steel lost during strike periods in the last five years has been a more important cause of deficit than lack of expansion.) We need the communities, now thriving because of steel plants, to recognize that the coke oven and blast furnace are industry's economic guarantee of their future.

A tax system that does not provide for replacement of worn-out equipment could wreck our plants as effectively as bombing. A tax system that works against the development of iron ore reserves has our key munitions industry always in doubt as to what the real ore situation will be in times of stress.

To the people of this audience it is my earnest plea that the real story be told. We are all in this boat together, and while the blast furnace crew may be only the "black gang" on this boat, they too are important.

To my friends among blast furnace men I wish to convey my humble appreciation for the hours they have spent to open my eyes to their problems. To my present associates, the operating group of Republic Steel, I wish to give credit. To Joe Slater, Frank Janacek, now gone, Walter Montgomery, Robert Liggett, Don Babcock, Walter Carroll, John Hazel, M. Fedock and others, I acknowledge my debt. The A. D. Little Co. men under the direction of Bruce Old who have lived with us are also a part of the group.

A new technique for microscopic observation is described. Conventional metallographic microscopes may be converted to "phase microscopes" by the addition of an annular stop in the illuminating system and a phase disk in the image of the stop.

Phase Contrast Metallography

THE GREATER the variety of conditions under which a metallographic specimen can be observed, the more information can be gained concerning it. The metallurgical microscope has been developed over the years until it has become a complex and versatile instrument. The more elaborate microscopes are equipped so that the operator may conveniently control various techniques of illumination and thus gain as much information as possible about the characteristics of the specimen. Up to the present time there have been three principal observation techniques offered: bright field, dark field, and polarized light. This article will describe an accessory which adds another technique, that of phase contrast observation, to current metallographic microscopes.

It is undoubtedly true that by far the greater part of the work done with the metallurgical microscope has been with central axial bright field illumination with full or slightly reduced aperture. Under such conditions, a properly polished and etched specimen is seen as being composed of crystals or grains. The grain boundaries generally appear as dark lines and the individual grains are lighter or darker than their neighbors according to their absorbing and scattering characteristics. Variations of bright field illumination that are of value for securing a relief impression of the specimen surface are obtained by the use of conical or half-aperture illumination or by using a decentered aperture diaphragm.

Dark field illumination produces images of high contrast and high resolving power. This technique is useful in studying surface conditions, as minute scratches and pits are made quite evident. It is also of value, although somewhat limited, in the identification of inclusions in steel.

Polarized light microscopy is finding wide favor as an aid in the identification of the constit-

uents of alloys, in revealing the structural phases in steel, and in the investigation of grain size. Measuring accessories for use with polarized light^{1, 2} permit quantitative measurement of the ellipticity and rotation of the polarization produced by the object. Also, very weak anisotropy is made visible with these devices.

In addition to bright field, dark field, and polarized light, we have recently developed an accessory permitting phase contrast observations to be made on current models of metallographic microscopes. Since the demonstration of this accessory at the Metal Show in October 1949, there has been considerable interest shown in the possibilities of phase contrast in metallography, and a technical description of it and what it can be expected to accomplish would seem timely.

The principles of phase contrast microscopy were first applied to the biological microscope in order to render visible, without staining, objects which are highly transparent. It is beyond the purpose and scope of this paper to go into the basic theory of the phase contrast microscope, a subject which has been adequately covered elsewhere.^{3, 4} It will suffice here to say that if an opaque specimen has elevated or depressed areas in its surface, normal methods of observation will show no more than the boundaries separating these areas, whereas the phase method of observation will render different heights visible as different shades of gray.

A normal bright field microscope is converted to a phase microscope by two additions:

By R. L. Seidenberg and J. R. Benford

Scientific Bureau
Bausch & Lomb Optical Co.
Rochester, N. Y.

¹References are on p. 727.

1. The illuminating beam is restricted to a hollow cone of light by simply inserting a transparent annulus in the illuminating system.

2. A phase-retarding annulus is located in the image of the transparent annulus after the light has been diffracted by the specimen.

This diffraction by the specimen is of a different nature than ordinary diffraction. Ordinary diffraction is caused by varying degrees of brightness in the specimen, whereas the diffraction which we are concerned with is caused by varying degrees of phase in the specimen. In transmitted light the varying degrees of phase may originate

dent light directly back to the eyepiece, casting a haze over the image. Secondly, the light has to pass through this absorbing material twice, resulting in a very large loss of light.

One solution of the foregoing difficulties is to locate the phase-altering annulus on the eyepiece side of the vertical illuminator.^{5,6} In this location only the image-forming rays pass through it and no harmful reflections or light losses are produced. Such an adaptation, however, poses serious mechanical problems and would very likely mean that the purchase of a new microscope would be required of the metallurgist.

The phase contrast system which is about to be described was designed for the purpose of providing an accessory unit for any of three current model inverted metallographic microscopes. Figure 1 shows the accessory in place on one of these microscopes. The unique feature of the system is that no special objectives or objective-illuminator units are required; all of the standard metallographic objectives as ordinarily used on these microscopes may be used. This is made possible by locating the phase annulus in an *image* of the objective aperture rather than in the aperture itself. To accomplish this a special lens system (C in Fig. 2) was designed to go in the position normally occupied by the camera eyepiece. This lens system performs the function of the camera eyepiece, but in addition is so designed as to form a well-defined image of the objective aperture, a condition which the normal camera eyepiece does not meet.

Figure 2 shows schematically the optical system of the phase unit in combination with the microscope. As is customary when employing Kohler illumination, the light source is imaged by a lamp condenser (not shown) at A, the plane of the aperture diaphragm. An annular stop, as indicated, is located at A. The condenser lens B images this stop at A', the rear focal plane of the objective. The objective forms an image of A' at infinity and, after reflection by the specimen, the annular stop image is re-imaged upon itself at A'. The special projection lens system C images A' at A'' and at this point the phase-altering annulus is located. A beam-splitting cube allows the greater part of the light to pass on out to the camera and directs the remaining light to the phase visual observation system.

Lens D converges the light and brings it to a focus for use with any standard eyepiece, E. The light rays drawn with a solid line are representative of the direct illuminating rays which are specularly reflected by the specimen; the dotted

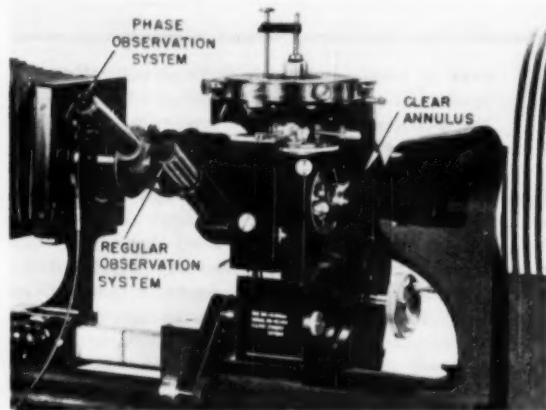


Fig. 1—Phase Contrast Accessories Attached to a Current-Model Microscope

from varying refractive index or varying thickness. In reflected light these differences in phase may come from varying surface elevation or varying specimen composition.

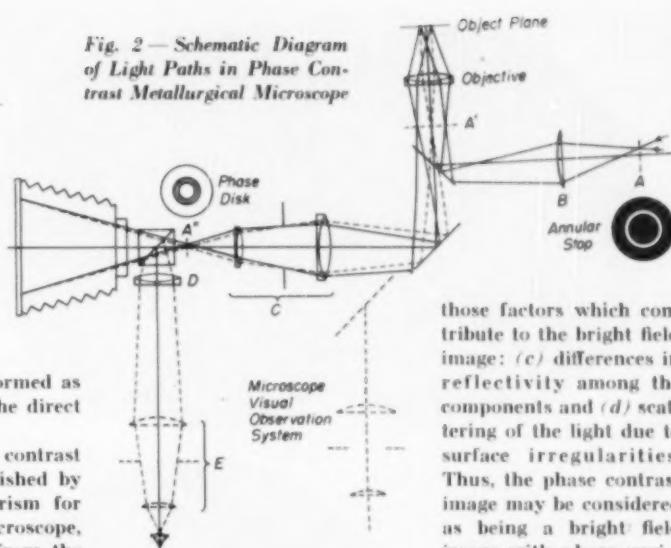
In the biological phase contrast microscope, the transparent annulus and the phase-retarding annulus, mentioned above, are located in the front focal plane of the condenser and the rear focal plane of the objective, respectively. It would seem, at first glance, that there would be no problem in adapting such a system to the microscope employing vertical incident illumination. There are, however, two serious complications which arise when a phase-retarding annulus is incorporated into a metallographic objective. The phase pattern is, in practice, made of two evaporated films. One film serves to retard in phase all light rays passing through it. The other film is an absorbing material and acts to reduce the intensity of the rays which are specularly reflected from the specimen. With vertical illumination this absorbing material reflects a substantial portion of the inci-

rays represent light which is "phase diffracted" by the specimen structure, hence is out of phase with the direct or undiffracted light energy. It will be seen that at A' the direct rays pass through the phase-altering region of the phase pattern while the diffracted rays pass through the clear glass portion of the phase disk. It is at this point that the diffracted rays are effectively retarded in phase by one quarter of a wave length of green light. The final phase image is formed as a result of interference between the direct and diffracted rays.

The switch-over from phase contrast to normal bright field is accomplished by simply inserting the reflecting prism for the normal visual tube of the microscope, and removing the annular stop from the illumination system. If the annular stop is left in place, observation will be under bright field conical illumination. For preliminary survey work the stop can generally be left in place, and the observer can quickly convert back and forth between phase and conical observation to determine whether phase contrast is adding to his knowledge of the specimen structure.

Photomicrography is carried out in the usual manner with the exception that once the light is directed for phase contrast use, no further redirection of the light is necessary for photography. A light-tight adapter is integral with the housing of the phase contrast unit. The manner in which to interpret properly the phase contrast image of an opaque specimen is rather complex. The pure phase contrast effects result from (a) irregularities in the surface level of the specimen, brought about by the polishing method or by the preferential attack of the etchant and (b) differences in the phase shift on reflection from the different constituents of the specimen. To these must be added

Fig. 2 — Schematic Diagram of Light Paths in Phase Contrast Metallurgical Microscope



those factors which contribute to the bright field image: (c) differences in reflectivity among the components and (d) scattering of the light due to surface irregularities. Thus, the phase contrast image may be considered as being a bright field image with phase variations made visible.

The unit has been designed to give positive, or dark, contrast; that is, regions of greater optical path in the specimen will appear darker than regions of shorter optical path. Thus, if a homogeneous specimen is under examination, light areas in the phase contrast image will indicate an elevated area in the specimen. Depressions, such as pits and grooves, will appear dark. Because phase contrast does make minute surface irregularities visible it should prove to be of value in the study of surface finishes.

In the study of nonhomogeneous specimens, the interpretation of the phase image becomes more complex, as phase shifts upon reflection from the various constituents will be made evident. F. W. Cuckow⁷ suggests that a thin film of aluminum be evaporated on the surface of the specimen in order that these differential phase shifts be eliminated on reflection. The image of a specimen so prepared would be influenced solely by variations of surface level, elevated areas appearing lighter

References

1. "Optische Messmethoden in Polarierten Auflicht", by M. Berek, *Fortschritte der Mineralogie, Kristallographie und Petrographie*, V. 22, No. 1, 1937.
2. "A Polarized Light Compensator for Opaque Minerals", by A. F. Turner, J. R. Benford and W. J. McLean, *Economic Geology*, V. 40, January–February 1945, p. 18.
3. "Phase Microscopy", by A. H. Bennett, H. Jupnik, H. Osterberg and O. W. Richards, *Transactions, American Microscopical Society*, V. 65, April 1946, p. 99.
4. "Das Phasenkontrastverfahren und seine Anwendung in der Mikroskopie", by A. Kohler and W. Loos, *Naturwissenschaften*, V. 29, 1941, p. 49. (Translation in *Textile Research Journal*, V. 17, February 1947, p. 82.)
5. "Phase Microscopy With Vertical Illumination", by H. Jupnik, H. Osterberg and G. E. Pride, *Journal of the Optical Society of America*, V. 38, April 1948, p. 338.
6. "The Phase-Contrast Microscope With Particular Reference to Vertical Incident Illumination", by E. W. Taylor, *Journal of the Royal Microscopical Society*, V. 69, May 1949, p. 49.
7. "The Phase Contrast Incident Light Microscope", by F. W. Cuckow, *Iron and Steel Institute Papers*, January 1949.

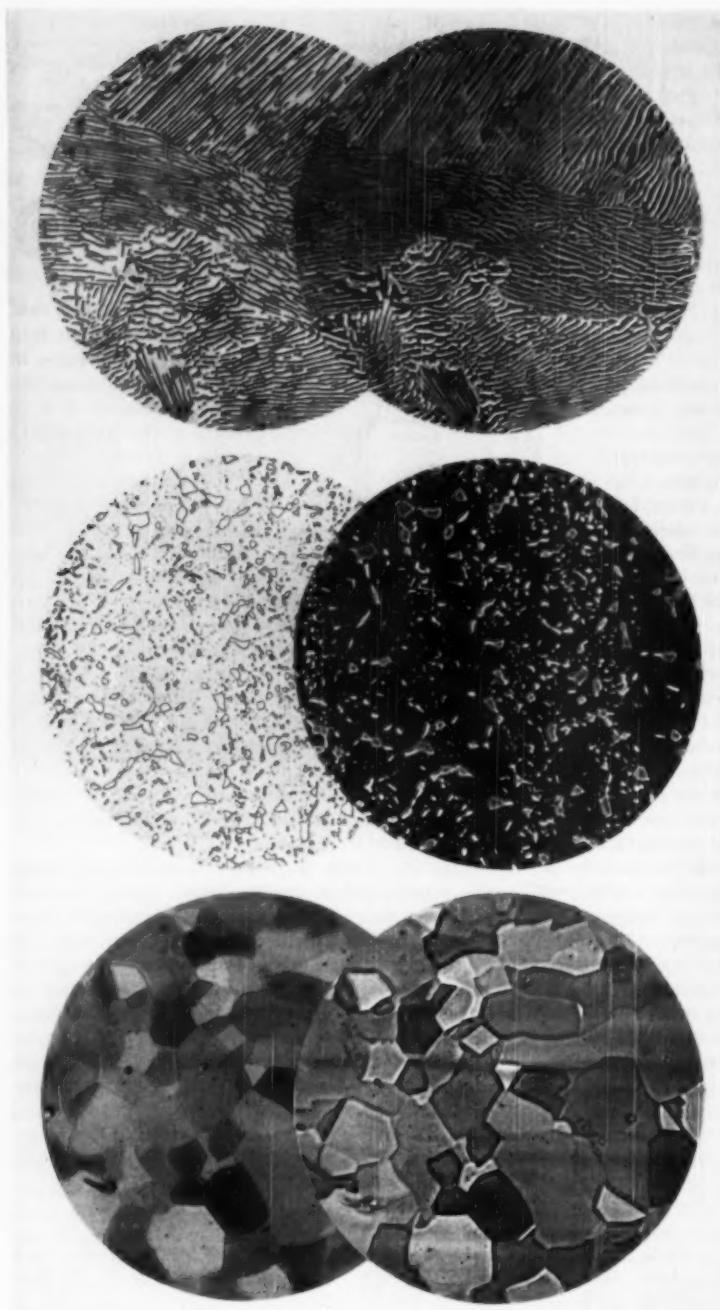


Fig. 3—Comparison Micrographs. Bright field (left) and phase contrast (right).
Pearlite at top, stainless steel at center, monel metal at bottom

than depressions. Such a method, however, would preclude the possibility of identifying constituents that would otherwise be recognizable.

Comparison Micrographs

Figure 3 shows comparison micrographs taken in bright field and phase contrast. Each bright field picture was taken using central axial illumination at approximately $\frac{2}{3}$ aperture. The pearlite lamellae and the carbide particles in the pearlitic and stainless steels, respectively, appear as a light shade of gray in the phase contrast pictures, indicating that these constituents are elevated above the general surface level of the rest of the specimen.

The phase contrast image of the monel sample provides excellent contrast between the various crystals in comparison with the bright field image, and adds information about the relative surface levels of adjoining crystals. As one passes a depression-elevation boundary, the light shades off in the depressed side and brightens up in the elevated side.

As more metallographers adopt the use of the phase contrast method, many interesting and valuable applications will undoubtedly be disclosed. A new and relatively unexplored field of research is offered to the metallurgist, and from this research may be expected further contributions to metal science.

Difficulties now existing in the foundry production of nodular iron (malleable, as-cast), due to necessary close control of inoculant and variation of properties with section size, may be removed by metallurgical improvements, such as desulphurization in basic cupolas by calcium carbide flux.

Nodular Iron: Theory and Practice

A CONFERENCE in mid-September, arranged by Howard F. Taylor of the department of metallurgy, Massachusetts Institute of Technology, attracted an international group of metallurgists and foundrymen who have been most concerned with the nurturing of this lusty infant of the foundry metals. It is only logical and proper that the scientific fundamentals be considered as the first item on the agenda, and consequently Alfred Boyles of the United States Pipe & Foundry Co. opened with a discussion of the mechanism of formation of flake graphite in ordinary cast iron, using the arguments set forth in his book on "The Structure of Cast Iron", published by the \bullet . Very, very briefly, the situation is this:

In a normal hypo-eutectic iron, austenite dendrites crystallize from the melt until the remaining liquid is of eutectic composition. Freezing of the eutectic then begins at crystallization centers independent of the previously solidified dendrites. At these crystallization centers flake graphite and solid gamma iron form together. Inoculation increases the number of eutectic crystallization centers to give smaller cells and the normal Type A graphite.

The opening salvo on the mechanism of formation of spherulitic graphite in cast iron was fired by H. Morrogh of the British Cast Iron Research Association (whose 1948 papers first introduced nodular iron to most American metallurgists). He pointed out that whereas graphite *crystals* consist of widely spaced hexagonal sheets, strongly anisotropic and with the basal plane of the hexagon parallel to the sheets, a graphite *spherulite* consists of an aggregate of crystallites radiating from a common nucleus, and the basal plane of each such crystallite is normal to the

radius of the spherulite. (Perhaps it is an evidence of the present state of knowledge that even this last statement is somewhat controversial. Some X-ray diffraction evidence was presented by Dr. Larsen of Dow Chemical Co. that graphite in spherulites may be rhombohedral with layers in ABC-ABC pattern instead of the usual hexagonal AB-AB pattern.)

Methods of Treatment — Mr. Morrogh stated that graphite spherulites could be produced in nine or ten different ways and that any theory as to the mechanism must find the common thread for all methods. Among the methods of producing graphite spherulites are the following: In the solid phase by annealing white-heart malleable castings high in sulphur and low in manganese; in as-cast cobalt-carbon and nickel-carbon alloys by treatment of the melt with either Ce, Ca, Mg, Zn, Cd, Bi (or in low-sulphur melts simply by rapid cooling); in hypereutectic irons by treatment with cerium; in hypo-eutectic or hypereutectic irons by treatment with magnesium. The two last methods are of some commercial importance and are patented.

Examples were also shown of good quality nodular graphite cast iron produced by treatment with calcium. Some spherulites were formed during freezing in a cast iron with very high sulphur, low manganese. In tellurium-treated irons, spherulites are often found just behind the chill. Bismuth was also found to be effective in causing some spherulites to form in cast iron during freezing. In pure iron-carbon alloys, merely rapid cool-

By Metal Progress's Special Representative

ing produced some spherulites. R. A. Flinn of the American Brake Shoe Co. added the interesting information that nodular graphite had been produced in thin castings by treating the molten metal with boron carbide, titanium carbide, and calcium carbide plus a magnesium salt.

A comparison of the magnesium and cerium treatments led to the conclusion that there may be no fundamental difference except that more cerium may be required to produce a given effect because of its higher atomic weight.

Theories for the formation of graphite spherulites involving nucleation and undercooling were discussed. Morrogh inclines to the view that extraneous nuclei (other than graphite) are not required, and that the spots observed microscopically in the center of spherulites are optical effects caused by the plane of polishing coinciding exactly with the basal plane of a radial crystallite. This view is not universal. For example, Professor De Sy presented evidence (in *Metal Progress* for June 1950) gained with electron microscope that a nongraphitic nucleus does exist, and chemical evidence that it is a magnesium compound in a magnesium-treated iron.

Furthermore, J. E. Rehder of the Bureau of Mines, Ottawa, Canada, described some studies on the nucleus. Evidence of both light and electron micrographs indicates that there is nuclear material other than graphite in the centers of the nodules. The nuclei appeared to be harder than the graphite composing the remainder of the nodule. Nodules from a magnesium-treated iron were separated by dissolving away the iron in weak acid and further separating other non-metallic inclusions by heavy liquid flotation. Measurement of over 1000 nodules gave an average diameter of about 50 microns with a distribution of sizes between 10 and 90 microns. Several samples of separated nodules were burned to remove the carbon and the ash analyzed. The MgO content of several samples of the ash showed only 1 to 4%. There was 30 to 50% Fe_2O_3 in the ash, some SiO_2 , and (surprisingly) TiO_2 in the order of 30 to 40%. No definite conclusions were drawn but Mr. Rehder indicated that nodules do form on specific (presumably nongraphitic) nuclei.

Foundry Production and Commercial Applications

Two schools of thought exist as to the commercial importance of nodular iron—one optimistic, the other much less so. Naturally enough, the optimistic view was taken by A. P. Gagnebin of International Nickel Co. in his discussion of "The Status of Ductile Iron in American Industry".

He pointed out that ductile iron (or nodular graphite iron), produced by magnesium treatment, is not a single material but a family of materials in which the matrix may be ferritic, pearlitic, martensitic, or austenitic—with properties varying according to the matrix structure. About 3500 tons of these various irons were produced last year and between 15,000 and 20,000 tons are expected to be produced this year. Properties obtainable in the various irons were reviewed and proposed specifications discussed. Examples of present commercial uses include compressor bodies, cylinders and pistons, rolls, axle housings, anvil blocks, gears, crankshafts, and plowpoints. According to Mr. Gagnebin, the useful combination of properties—the process advantages of cast iron with the product advantages of both iron and steel—will eventually place ductile iron third in tonnage among ferrous metals, immediately behind rolled steel and gray cast iron and ahead of malleable iron and cast steel. Truly a bright future!

A considerably less hopeful view was taken by Harold Bogart of Ford Motor Co. who reviewed the subject from the large-tonnage automotive foundryman's standpoint. Extensive test data were shown for two basic irons, correlating the effect of section size and of varying magnesium contents on the mechanical properties of the castings. Effects of heat treatments were also shown. Mr. Bogart pointed out that optimum properties are obtained only within a narrow range of magnesium content—around 0.04 to 0.05%—a range which is exceedingly difficult to maintain in production. Properties of heavy section castings are considerably poorer, and increasing the magnesium does not improve them. Other problems mentioned were the gating and feeding of castings to prevent shrinkage and the marked segregation sometimes encountered. All in all, he felt that nodular iron may not become the widely used material of commerce that Mr. Gagnebin predicted.

Some, at least, of the present hurdles may be jumped by improvements in foundry metallurgy, either known at present or to be perfected in the future. For example, the efficiency of magnesium or cerium additions to produce nodular iron seems to be dependent primarily on the sulphur content of the base iron. With low-sulphur iron the nodulizing alloy addition may be one third that required for an ordinary cupola iron. The problem is to get low-sulphur iron from the coke, pig iron and scrap now available by some method that costs less than the inoculating reagent otherwise required. C. K. Donoho of American Cast Iron Pipe Co. called attention to the achievements of the basic lined cupola in this respect.

When the cupola is lined with magnesite

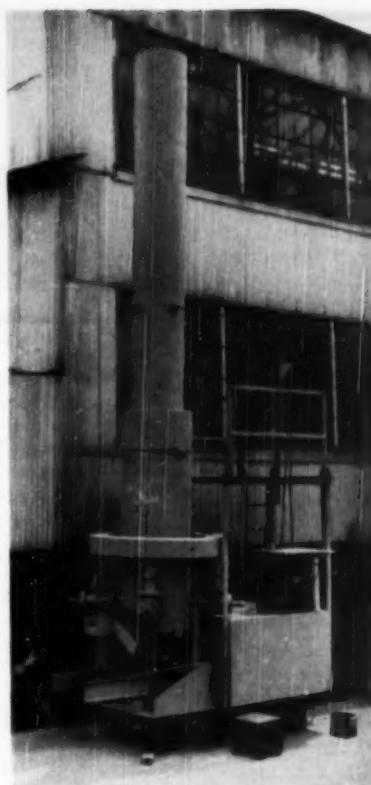
brick and a basic, reducing slag made with commercial calcium carbide as the flux material, remarkable desulphurization can be accomplished in the cupola. One heat cited averaged 0.009% sulphur. Concomitant results of this basic practice are higher melting temperatures and increased carbon pickup. It was shown that high-quality, low-sulphur iron can be produced by the basic cupola practice from either 100% cast scrap or 100% steel scrap, and the overall economics of the process seems to be favorable for commercial production of nodular iron.

John Chipman of Massachusetts Institute of Technology ably outlined the physical chemistry of desulphurization. The role of alumina in basic slags was clarified; although Al_2O_3 acts as an acid in basic slags it is not an oxidizing agent as SiO_2 may be, and consequently does not retard desulphurization as strongly as does SiO_2 .

Genesis of the Nodules

A very interesting interchange of views was had upon the genesis of the graphite spherulites, in the sense of the *time* during the solidification process in which they appear. Mr. Morrogh told of some quenching experiments on cerium-treated hypereutectic irons which indicate that graphite spherulites form in the liquid metal prior to the eutectic arrest. This is also evidenced by flotation of such nodules; they appear to be closer together in the upper parts of heavy sections. In hypo-eutectic irons treated with magnesium the eutectic arrest is smoothed out but the evidence is not clear as to whether the spherulites form in liquid or in solid metal.

In this connection Prof. Albert De Sy of the University of Ghent, Belgium, described current research on "spheroidal" graphite cast iron in his country. Examples were given of cast iron containing graphite spherulites in the as-cast condition, produced by treatment of the molten iron



Experimental Cupola, Basic Lined, Capable of Producing 0.006% S Iron (American Cast Iron Pipe Co.)

with Ce, Mg, Li, Ca, Sr, Na, or Te. The last two produced irons which were only partially nodular. In discussing the mechanism of formation of graphite spherulites in cast iron, Prof. De Sy showed some typical cooling curves through the freezing range for several nodular and flake graphite irons. The nodular irons have a much less definite eutectic arrest than do the flake graphite irons. With regard to the question of when nodules are born, he thinks the spherulites may form either in fully liquid metal or in fully solid metal, but never at the solid-liquid interface, where presumably flake graphite forms.

Summary

Although called by almost as many different names as there are speakers on the subject, the production and properties of nodular irons are now generally understood. It is apparent that at least ten different elements can be used to treat molten iron to produce graphite spherulites in the solidified metal. Of these, one group

is composed of strongly alkaline desulphurizers, such as magnesium, cerium, lithium and calcium. In an entirely different group are such acid elements as sulphur, selenium, and tellurium. The latter elements are most effective in low-manganese irons.

In hypereutectic iron there is ample evidence that graphite spherulites separate from the wholly liquid phase. In hypo-eutectic irons the evidence is not yet clear. Although all precipitation of a solid phase must be by a process of nucleation and growth, there is yet no precise and acceptable evidence that the microscopically visible nuclei in nodules at high magnifications consist of anything other than graphite.

The conflicting opinions as to the eventual commercial position of this new material relative to the older ferrous foundry metals will be resolved only by time and experience.

Correspondence

Cathodic Vacuum Etching

LONDON, ENGLAND

Messrs. McCutcheon and Pahl, in their article in *Metal Progress* for November 1949 (p. 674), state that cathodic vacuum etching of metals should be of considerable interest to metallographers. Thus a method which was divulged 25 years ago is at last put into extensive use.

Their literature references note that W. Feitknecht published the first article in Switzerland in 1924, and Cyril Stanley Smith another in England in 1927. This note is to record the fact that the present author contributed a memoir to the Polish Academy of Sciences in 1925 (*Bulletin*, 1925, Series A, p. 81 to 92) on "Cathodic Sputtering of Alloys". The work was done in the physics department of the University of Warsaw under Professor Pienkowski. Sputtered films and the structure on the surface of the sputtered specimens were photographed; the latter gave a very delicate design, quite similar to that obtained by conventional etchants. A variety of alloys were studied including solid solutions such as α Cu-Al, eutectic alloys such as Bi-Cd, and alloys with intermetallic compounds such as Sb-Zn. It is clearly pointed out that the method can distinguish between the polished surfaces of pure metals (solid solutions) and highly dispersed heterogeneous structures.

JÓZEF MAZUR
Metallurgy Department
Royal School of Mines

Transfer of Replica From Metal to Electron Microscope

BLAWNOX, PA.

Metallographers usually depend on Scotch tape and a specimen screen to remove the Formvar replica from a metallic surface, prior to examining

this replica under the electron microscope. As many will attest, this scheme leaves much to be desired; whenever the replica really sticks to the metal, the Scotch tape cannot remove it. We have found that a much better scheme is as follows:

The specimen screen, prior to being placed against the surface of the Scotch tape, is first immersed in a very dilute solvent solution of resinous materials, plasticized so that upon drying a very tacky adhesive ensues. After immersing, the screen is removed from the adhesive solution and the center portion openings of the screen are blown free of the plastic material by an air stream from a micropipette. The air should be dry and of sufficient volume to evaporate the solvent of the mixture. The screen is then placed against the surface of the Scotch tape and the remaining procedure carried out as usual. By this means the screen has been effectively coated with an adhesive film which does not affect its porosity and which effectively adheres to and helps remove the plastic replica and which remains stable within the electron microscope under conditions of vacuum, heat and electron bombardment.

HAROLD C. O'BRIEN, JR.
Director of Research
Royston Laboratories, Inc.

Galvanic Macro-Etch for High-Purity Aluminum

CAMBRIDGE, MASS.

In a study of the recrystallization of high-purity aluminum (Cu 0.002%, Fe 0.03%, Si 0.06%, Mn 0.001%, Mg <0.001%), a very simple macro-etching technique was used to prepare the samples, which were polished before heat treatment with 000 emery paper coated with paraffin. The recrystallized aluminum bars were dipped for about three quarters of their length into a 15% solution of HCl and externally coupled with an 18-8 stain-



Recrystallized Aluminum Rods Etched by Galvanic Action. Enlarged 1.2 diameters

less steel rod dipped into the same solution. After a suitable time, the aluminum bars were removed, rinsed in water, rinsed in alcohol or acetone, and dried. This was then repeated after reversing the position of the bar to etch the unetched top portion. In doing so the center of the bar was doubly attacked, but this is desirable since the portion is etched more slowly near the surface of the electrolyte.

The galvanic action due to coupling with a more noble electrode increases the etching rate and gives a better contrast to the final structure. The galvanic action is stronger the larger the ratio of the cathodic (stainless steel) to anodic (aluminum) surface immersed in the electrolyte.

The electrolyte concentration and other conditions are not at all critical. The acid concentration and the ratio of cathodic-to-anodic areas should be adjusted in order to obtain a good etch in about 5 min. If the rate of attack is too fast, the metallographic structure appears uneven and sometimes stained. On the other hand if the rate of attack is approximately right, longer times of treatment do not give undesirable overetching within very broad limits of time. As a rule, the coarser the grain size, the milder the condition of attack should be.

This galvanic etching is also suitable for revealing the macrostructure of aluminum of higher purity. It was not satisfactory for annealed 2S aluminum; whether this is due to the associated alloying elements in commercial aluminum or to the structure of our sample is unknown.

A note on our method of making the large

crystals may be of interest. Several $\frac{3}{8}$ -in. rods as-received were machined to 0.30-in. diameter. The lower rod in the illustration (grain size 0.05 to 1.3 mm.) was annealed 30 min. at 700 to 775° F. The middle one (grain size 3.5 mm.) was annealed 13 hr. at 1150° F., stretched 3 to 4% and re-annealed 17 hr. at 1150° F. The top one (monocrystal 1½ in. long) had the following history: Anneal 30 min. at 1100 to 1150° F.; cool; bend 1½ in. from each end; straighten by hand; re-anneal at 1100 to 1150° F. overnight.

I. S. SEAVI
Research Assistant
Metallurgy Department
Mass. Institute of Technology

Hallowe'en

PHILADELPHIA, PA.

When the frost is on the pumpkin, hob-goblins stalk the land. They even get into ball bearings!

The light pattern in the large steel ball (made of S.A.E. 52100) is a low-carbon steel inclusion and the photograph is exactly as the ball appeared after hardness testing and then etching in hot 50% hydrochloric acid.

The low-carbon inclusion resulted from the steel plate, which is normally attached to the top of the ingot mold plug, breaking away and floating up into the molten steel. This plate is used to prevent impingement of the molten steel directly on the plug, which might result in fragments of the plug getting into the steel. After rolling and drawing into ball wire and pressing into balls, the plate took the form shown in the photograph of the round ball.

H. O. WALP
Chief Metallurgist
S.K.F. Industries, Inc.



Thermal Polishing and Etching

LONDON, ENGLAND

We are interested to read the letter from Glen W. Wensch (*Metal Progress*, April 1950, p. 488) describing phenomena observed on the surface of nickel specimens after long times of annealing in sealed evacuated tubes. Under these conditions a considerable redeposition of nickel on the specimen from the vapor phase would be

expected, and this may well contribute to the polishing effect observed. However, we believe that surface migration is a more potent mechanism; this will act in such a way that the free energy of the surface is reduced, as will occur if the surface area is diminished by the removal of scratches and other irregularities.

Although Mr. Wensch does not refer to any investigation of these processes earlier than 1941, R. Shuttleworth (*Metallurgia*, Vol. 38, 1948, p. 125) in a review of the subject gives 1910 as the date of the first observation of thermal etching (W. Rosenhain and J. C. W. Humfrey, *Proceedings of the Royal Society*, Vol. A83, 1910, p. 200). The earliest date at which thermal polishing was noticed appears to be 1938 (R. P. Johnson, *Physical*



Equilibrium Surface of Nickel Rod (75 \times) Heated Under Slight Compression in Vacuum to 1110° C., Showing Effects of Viscous Flow and Grain Growth

Review, Vol. 54, 1938, p. 459), although three years previously E. N. da C. Andrade and J. G. Martindale (*Philosophical Transactions of the Royal Society*, Vol. A235, 1935, p. 69) had shown that surface migration could take place at 280° C. on silver. In view of Mr. Wensch's last paragraph he will no doubt be interested to read the paper by M. J. Day and J. B. Austin (*A.S.M. Transactions*, Vol. 28, 1940, p. 354) on the determination of austenite grain size by this technique.

In the laboratories at the University of Cambridge we are using this technique to examine metals at elevated temperatures, using a reflecting microscope. While we find that the equilibrium surface is rarely as smooth as a mechanically polished surface, the irregularities are of interest in

themselves, being related to the internal structure of the metal. We can confirm Mr. Wensch's observations on nickel and the accompanying photograph shows some additional interesting features. The photograph (magnification of 75 \times) was taken using plane-polarized light, and is of a 99.9% nickel dilatometer specimen of $\frac{3}{8}$ -in. diameter. This has been slowly heated to 1410° C. (2570° F.) in vacuum under a small load, and it can be seen that the original machining grooves have been rounded and reduced in depth. Under the load, creep has occurred (about 1% compression), principally of the "viscous flow" type in the grain boundaries, as is shown by the ridges formed by the metal which has been squeezed out. The furrow along the top of each ridge shows the original location of the grain boundaries as revealed by thermal etching. Subsequent grain growth has eliminated a small grain originally at the center of the field and larger polyhedral grains have been formed with boundaries meeting at about the equilibrium angle of 120°. During this recrystallization and growth, twinning has also occurred, shown by the development of texture on the surface of the specimen.

We concur with Mr. Wensch that the phenomenon is of intrinsic interest and is undoubtedly proving to be a valuable extension to available metallographic methods.

A. G. METCALFE and M. J. OLNEY

Department of Metallurgy
University of Cambridge

Circular Graphite in Cast Iron

BIRMINGHAM, ENGLAND

The letter published in the April issue of *Metal Progress* from C. K. Donoho is interesting, but I can only believe that the term "exclusive development" refers to the words used, namely, "circular graphite", and not to the structure itself. This structure has been produced and described in the literature previously. For instance, the structure was produced by Morrogh in high-sulphur cast irons and illustrated in the *Journal of the Iron and Steel Institute*, No. 2, for 1946, Fig. 13 to 17, although the term "circular graphite" was not used. The structure was also referred to by Morrogh and Williams in the *Journal of the Iron and Steel Institute* for March 1947. In these references the term "mesh" or "mesh-like" graphite has been used. More recent references to this type of structure have appeared in the *Journal of Research and Development* of the British Cast Iron Research Association for February 1950, and also some perfect illustrations have been given still

more recently by Williams in the April 1950 issue of the *Journal of the Iron and Steel Institute*.

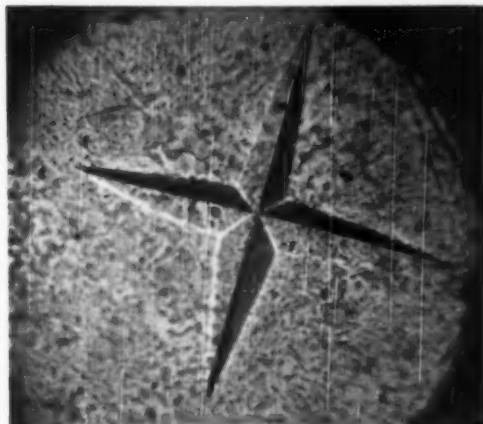
Mr. Donoho suggests that further work will be directed to "how to make it again". The answer to this will be found in the above references. I can only say that I am in sympathy with him when he says "what to use it for and why make it at all."

H. MORROGH
Research Manager
British Cast Iron Research Assoc.

Star Fish or Compass-Rose?

LONDON, ENGLAND

Being a quadruped it cannot be a star-fish! Likewise, the attractive compass-rose is not taken from an old chart, but is the result of two indentations with a double-conical diamond indenter on a specimen of cast tin. Crossing of indentations is not a technique to be recommended; possibly when it occurs accidentally it ought not even then be published. Nevertheless, readers may be inter-



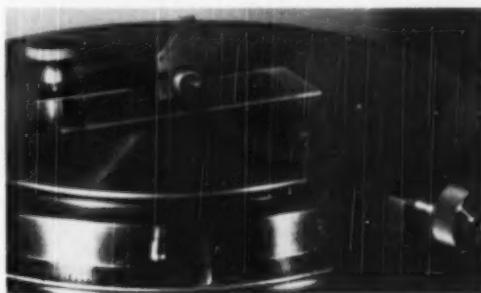
ested to note that the first indentation is practically of the same length as the second one, thus revealing no work hardening. In the present case the "Double Cone" hardness is $H_{dc} = 21$ kg. per sq.mm. The measured Vickers hardness (diamond pyramid) is $DPH = 18$ kg. per sq.mm. Applied load was 50 g., the magnification 400 \times . The advantage of the Double Cone indenter is the elongated impression similar to that obtained with the Knoop indenter.

W. STERN
Diamond Research Department
Industrial Distributors (Sales) Ltd.

Quick Estimation of Case Depth

BLOOMFIELD, N. J.

In the production of small parts we frequently desire to check each batch for case depth as it comes from the Homo-Carb furnace; therefore we do not want to take the time required to mount them in bakelite. The sample (in the illustration



Thin Sample Held to Microscope Slide by Plastic Clay; Polarized Light Avoids Reflections From Surface of Glass Slide

it is a float arm, about $\frac{1}{2} \times \frac{1}{2}$ in., punched from 0.035-in. mild steel) is ground on a fine-grit grinding wheel, followed by a few strokes on No. 00-grit emery paper. This surface is smooth enough to bring out the case with a 2% nital etch. Then the sample is placed on a glass microscope slide and is held erect by small pieces of modeling clay. When the slide is placed on an inverted-type microscope and viewed with polarized light, the case is easily measured with a micrometer eyepiece. (With the usual bright-field illumination, reflected light is deflected by the glass slide and it is impossible to see the sample.)

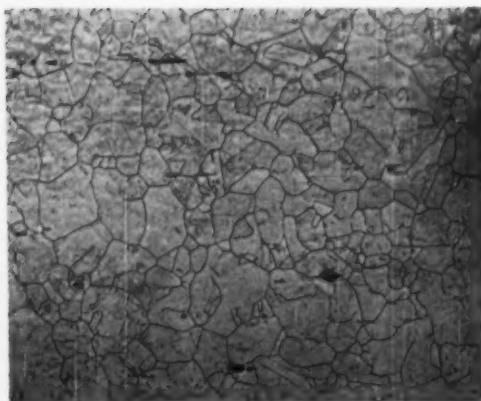
If it is necessary to see the grain size or to get a rough estimate of structure, the sample can be given the usual polishing and etching steps following the grinding, and the polarized light will outline the grain boundaries.

MARIE H. WHITEHILL
Metallographer
Air Conditioning Department
General Electric Co.

Electrolytic Polishing of Nickel

LOS ALAMOS, NEW MEXICO

Since manual polishing, followed by chemical etching of nickel, is a time-consuming process, often producing an inferior surface due to surface distortion and the lack of strong preferential



Nickel, Annealed at 800° C. (1475° F.) for 25 Min., Electropolished and Electro-Etched

chemical action demonstrated by most etchants toward nickel, a rapid method of surface preparation was sought in a recent investigation of recrystallization of plastically deformed nickel. Various existing procedures of electropolishing nickel were evaluated, and the most promising method was that of Hothersall and Hammond ("The Anodic Polishing of Electrodeposited Nickel", *Journal of the Electrodepositors' Technical Society*, Vol. 16, 1940, p. 83).

However, experience indicated that this should be modified for best results to the following:

Solution : 390 cc. concentrated sulphuric acid plus 290 cc. distilled H_2O .
Cathode : Nickel
C.D. : 39 amperes per square decimeter
Time : 4 to 6 min.
Temperature: 95° F. maximum

In some instances the electropolished surface had such high reflectance that difficulty was encountered in focusing the microscope! The solution described above did not etch when used at lower current densities.

An investigation of many common reagents revealed that the nickel so polished could be beautifully electro-etched according to the following formula:

Solution: 53 cc. 85% orthophosphoric acid to 100 cc. distilled H_2O .
C.D. : 1.55 amperes per square decimeter
Time : 1 to 4 min.

The accompanying figure clearly shows the excellence of this method.

GLEN W. WENSCH
Los Alamos Scientific Laboratory

NOTE: These investigations were carried out while the author was at the University of Illinois.

Permanent Record of Magnaflux Indications

COLUMBUS, IND.

Frequently it is necessary, for record purposes, to make Scotch-tape prints of defects found by the magnetic-particle inspection method. The procedure commonly used is to obtain the particle pattern of the defect in the normal manner from a suspension of the black paste in Stoddard's solvent. Then you have a choice of allowing the solvent to drain off for several hours, or (preferably) let the sample drain overnight in a dust-free room. Or, you may flow carbon tetrachloride cautiously over the pattern, hoping it will not wash partly away.

The writer has found a quick way of preparing the sample so a tape print can be made in a few minutes, by using a 1½% (by volume) suspension of the black paste in carbon tetrachloride. Clean off all oil or grease from the area where the defect is located, or degrease with any of the usual quick drying solvents. Then, while the magnetizing "shot" is put through the part, flow on the powder suspension in carbon tetrachloride. In about a minute the solvent evaporates and the print can be made.

The gray background that appears on such a print, due to scattered magnetic particles which did not drain off, is no worse than that obtained by the old method. We also find that prints of very fine, subsurface indications can be obtained with the suspension in CCl_4 which could not be obtained before.

HAROLD H. LURIE
Chief Metallurgist
Cummins Engine Co., Inc.



Personal Mention



Othmar H. Ammann

A 25-year-old Swiss, just graduated in civil engineering, came to America in 1904 and got a job with the Pennsylvania Steel Co. Immediately he found himself working on minor problems connected with the production of nickel steel eyebars for the Queensborough Bridge in New York City, and here began **Othmar H. Ammann's** life-long career in big bridges. From 1909 to 1912 he was associated with the consulting engineers who investigated the tragic failure of the world's largest cantilever bridge across the St. Lawrence at Quebec. From 1912 to 1925 he was associated with Gustav Lindenthal; as assistant chief engineer of the New York Connecting Railroad, he was in charge of the construction of the Hell Gate Bridge across the East River in New York, at the time the longest arch in existence.

From 1925 to 1939 Mr. Ammann occupied successively the positions of bridge engineer, chief engineer and director of engineering of the Port of New York Authority, and from 1934 also that of chief engineer of the Triborough Bridge Authority. In these capacities he directed the engineering and execution of such major projects as the George Washington Bridge, the Bayonne Bridge across the Kill van Kull, the Triborough and Bronx-Whitestone bridges across the East River with their extensive approaches.

In all of these he has made extensive use of alloy steels, and thus amply warrants the A.S.M.'s Distinguished Service Award "for extensive

Gordon Johnson, past-chairman of the North West Chapter of the American Society for Metals, has joined Armour Research Foundation as supervisor of foundry process research. He was previously chief metallurgist of the American Hoist & Derrick Co., St. Paul, Minn.

J. L. Wyatt is attending Massachusetts Institute of Technology for graduate study. He was formerly employed by the Titanium Div. of National Lead Co. and the company is sponsoring his research work.

W. Wallace Brenneman is now metallurgist for the Crawford Steel Foundry Co., Bucyrus, Ohio.

F. C. Albers has been transferred by Chicago Pneumatic Tool Co. from the Detroit manufacturing facilities to the new plant at Utica, N. Y. At the same time he has been promoted to chief metallurgist.

George W. Hastings, formerly president of Milford Metal Treating Co., Inc., has established a heat treating plant in Benton Harbor, Mich., known as Harbor Metal Treating Co.

James Miller, who was formerly with the Cornell Aeronautical Laboratory, Buffalo, N. Y., has recently joined the Thomson Laboratory of the General Electric River Works, West Lynn, Mass., as a metallurgist.

H. A. Cavanagh is now a sales-service engineer in the Chicago area for Crucible Steel Co. of America.

Edward H. Burrs has been transferred by Crucible Steel Co. from the Cincinnati office to the newly established Dayton, Ohio, office.

application of the strong structural steels for long-span highway bridges". The George Washington suspension bridge built by the Port of New York Authority, which with its span of 3590 ft. far surpassed previous structures of its kind, contains 32,000 tons of silicon steel. Othmar Ammann is not bound by convention, for in the Bayonne Bridge, the longest existing arch, he used high-strength manganese steel for the first time in bridge history, being convinced of its advantages in competition with other structural alloy steels for the exceptionally heavy compression members composing the arch ribs.

Climax Molybdenum Co. of Michigan announces the appointment of **Walter F. Craig, Jr.** as metallurgical engineer in the Chicago office. He was previously supervisor of ferrous metals research at Armour Research Foundation.

The Midvale Co., Philadelphia, announces that **A. R. Gaus** has been named assistant to the vice-president in charge of sales. Mr. Gaus had represented the Midvale Co. in the Pittsburgh office since 1937.

Roll Manufacturers Institute, Pittsburgh, announces that **Joseph J. Marsalka**, for the past five years research laboratory supervisor of Blaw-Knox Co., has been appointed technical director of the institute.

D. S. Chambers has joined Vanadium-Alloys Steel Co., Latrobe, Pa., and is on the research and development staff of the metallurgical department.

A. A. Bradd, formerly assistant superintendent of research and of heat treatment for the Midvale Co., is now supervisor of heat treatment for the Philadelphia Gear Works.

After receiving his M.S. degree from Michigan College of Mining and Technology in August, **Earl C. Sutherland** has been appointed a technical engineer with the International Business Machines Corp., Endicott, N. Y.

George F. Burditt has been transferred by Wheelabrator & Equipment Corp. to Greensboro, N. C., to open a new sales office for the areas of North Carolina, South Carolina, Virginia, West Virginia and northeastern Georgia.

After graduating from the University of Washington in June, **William K. Gibb** has joined Boston Electro Steel Foundry as an inspector of castings.

Francis W. Shepherd, who recently completed the requirements for the degree of master of science in mechanical engineering at the University of Minnesota, has accepted a position as mechanical engineer at the U. S. Naval Proving Ground at Dahlgren, Va., in the experimental department.

Vernon H. Jones has been appointed assistant metallurgist in the foundry of the Canadian Westinghouse Co., Ltd., Hamilton, Ont.

Frank V. Bednarczyk, Jr., who graduated from the University of Detroit in June, has been employed at Hewitt Metals Corp., Detroit, as plant engineer.

Personals

R. W. Sandelin **Q** has been appointed head of the metallurgical department of Connors Steel Co., Birmingham, Ala.

E. E. Staples **Q** has been promoted by Hevi-Duty Electric Co., Milwaukee, from district sales manager of the Cleveland area to vice-president in charge of sales.

H. H. Hewitt, Jr., **Q** is now with McCulloch & Sons, Portland, Ore.

E. L. Bartholomew, Jr., **Q**, for the past 12 years on the teaching staff of Massachusetts Institute of Technology, has accepted an appointment as associate professor of mechanical engineering at the University of Connecticut.

Karl Thomas Aust **Q**, who received his Ph.D. in June from the University of Toronto, is now research metallurgist in the X-ray diffraction division of Kaiser Aluminum and Chemical Corp., Spokane, Wash.

C. A. Sellen **Q** has been appointed assistant to the general manager of the Reliance Div. of Eaton Mfg. Co., Massillon, Ohio. He joined the division in 1939 as chief metallurgist.

Edgar C. Buckingham **Q**, who graduated from the University of Southern California in June, is now employed in the traffic department of Monolith Portland Cement Co. as assistant traffic manager.

Albert G. Haynes **Q** is now project engineer in plant engineering department of Koppers Co.'s recently acquired engineering department.

Edward D. Weisert **Q**, who graduated in August from the University of Michigan, has accepted a sales engineering position in the Chicago district office of the Haynes Stellite Div. of Union Carbide and Carbon Corp.

Werner Blumenthal **Q**, who received his degree from the University of Michigan in June 1950, is now employed as a process engineer with AMI, Inc., Grand Rapids, Mich.

Mark M. Templeton **Q**, who for the past two years has been superintendent at the Sheffield, Ala., plant of the Electro Metallurgical Div. of Union Carbide and Carbon Corp., has been appointed assistant to the works manager of the division and will be located in Niagara Falls, N. Y.

After receiving his Ph.D. from Illinois Institute of Technology in June, Frank A. Crossley **Q** has been appointed director of the department of metallurgical engineering of Tennessee Agricultural and Industrial State College.

Frederick V. Horak **Q** has been transferred by Allis-Chalmers Mfg. Co. from West Allis works to become plant metallurgist at the LaCrosse works, LaCrosse, Wis.

C. Donald McLain **Q**, formerly with Spang-Chalfant Div. of National Supply Co., is now metallurgical engineer with Western Brass Mills Div. of Olin Industries, East Alton, Ill.

Raymond C. Landstrom **Q**, formerly sales representative for the Latrobe Electric Steel Co. in Rockford, Ill., is now vice-president in charge of manufacturing of the King & Hamilton Co., Ottawa, Ill.

Bruce M. Shields **Q**, formerly research metallurgist of the South works, Carnegie-Illinois Steel Corp., has accepted a research assistantship at Massachusetts Institute of Technology and will work toward his Doctor of Science degree.

Goldye Cohen Leeds **Q**, formerly with I. Stern & Co., Inc., is now a technical writer for the Signal Corps Publications Agency, Fort Monmouth, N. J.

FOR LONGER TOOL LIFE, LOWER TOOL COSTS, AND QUALITY HIGH SPEED STEEL HARDENING . . .



Sentry Model "2Y" — For hardening small tools and cutters of moly, tungsten and cobalt high speed steels.



Sentry Model "5Y" — For handling larger tools and cutters. Flexible, economical, quick to heat up.



Sentry Model "YP"—Vertical Furnace for hardening long, slender drills, reamers, broaches, etc.

SENTRY ELECTRIC FURNACES

Sentry Electric Furnaces produce quality hardening, maximum toughness and exceptional durability in high speed steel and high carbon high chrome. Edges stand up longer which means less frequent grindings, longer tool life and lower tool costs.

Sentry Furnaces utilize Sentry Diamond Blocks permitting full soaking of tools without danger of burning. No scaling. No decarburization. Produce a clean finish which eliminates finishing operations.

Ask for catalog A20



The Sentry Company

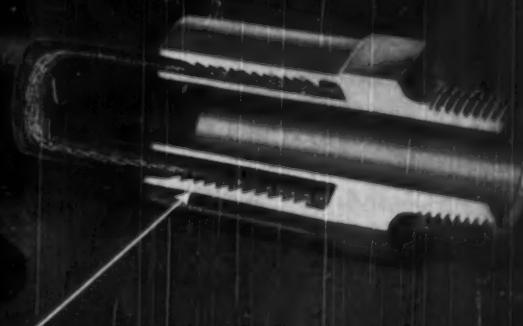
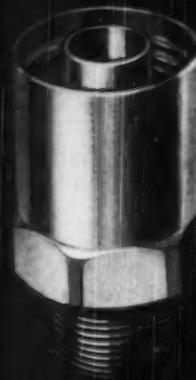
FORT BOSTON, MASS., U.S.A.



REVERE Free Cutting Brass Rod Makes

"Duck Soup"

out of Deep Recesses!



Clean under-cuts in a deep and accurate recess

ANYONE who has set-up a lathe or toolled-up an automatic can see at a glance that the Eastman Pressed-On Hose Coupling is not the easiest thing in the world to machine from the solid.

On one end the boring, chamfering, deep turning to a pipe thread taper up to a round shoulder, and threading, are neither very difficult nor very easy to handle.

But look at that deep recess on the other end! It has reverse under-cut annular serrations that are so clean and accurate that the coupling holds a hydraulic hose with a grip that is stronger than the hose itself.

Anyone who had to do that job would want to work on a material which had all the ease of machining and uniformity of behavior under the cutting tools he could get. That is why the Eastman Manufacturing Company, Manitowoc, Wisconsin, uses 1 1/8" diameter Revere Hexagon Free Cutting Brass Rod in this patented coupling. All of the production problems are in the tools, none are in the material.

The difficult tasks are not the only ones on which the ultimate of machinability will pay off. If you want to work to combinations of speeds and feeds and accuracies which are even a little bit beyond the ordinary, or you have a job which is even a minor challenge to your tool makers and your set-up men, then Revere Free Cutting Brass Rod may be your best friend.

It will not cost anything to find out. Just get in touch with your nearest Revere Sales Office.

REVERE
COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

*Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities, Distributors Everywhere.*

Personals

Anton L. Schaeffer (2), formerly with the Arcos Corp., has joined Allis-Chalmers Mfg. Co., Milwaukee, as a metallurgical engineer.

William F. Tuff (2), who graduated from the University of British Columbia this year, is now with the Steel Co. of Canada, Hamilton, Ont., works, in its training program.

Frank P. Denzel (2) has established the Franklin Supply Co., Columbus, Ohio, to distribute welding supplies in central Ohio for Linde Air Products Co. and Metal & Thermit Corp.

Harold D. Wilson (2) has been appointed vice-president of the Gary Steel Supply Co., Chicago. He has been with the company since 1943.

Zay Jeffries (2), former vice-president of the General Electric Co., has been appointed Leonard Case professor and consultant on education policy of Case Institute of Technology, Cleveland.

F. Wesley Smith (2), formerly New England manager for D. A. Stuart Oil Co., has opened consulting offices at Holliston, Mass. He will specialize in lubricants and their applications.

After graduating from Case Institute of Technology, **Henry Kopczewski** (2) has been appointed foundry metallurgist in the research laboratory of Apex Smelting Co., Cleveland.

Charles C. Hicks (2) is now supervisor of the engine dynamometer laboratory test engineers for the Ford Motor Co.'s engineering research department, Dearborn, Mich.

C. W. Haynes (2) is on leave from the faculty of the University of Nebraska and will study at the department of metallurgical engineering, Carnegie Institute of Technology, under an Atomic Energy Commission postdoctoral fellowship.

Merrick F. McCarthy, Jr., (2) has recently joined the Peerless Foundry Co., Cincinnati, as metallurgist.

William W. Berkey (2) is now an instructor of aircraft structural repair and aircraft heat treatment for the Department of the Air Force at Chanute Field, Ill.

Joseph E. Hagins (2), formerly with Sheffield Steel Co., Houston, Tex., is now maintenance superintendent for the A. O. Smith Corp. of Texas.

James J. Kubbs (2), formerly metallurgist of the Modern Steel Treating Co., Cleveland, has accepted a position as metallurgist of the chain division of the Jeffrey Mfg. Co., Columbus, Ohio.

Caterpillar Tractor Co., Peoria, Ill., announces the appointment of **J. R. Munro** (2), formerly general factory manager, to the newly created position of director of manufacturing; **C. A. Woodley** (2) will be the new general factory manager; **W. L. Naumann** (2) and **Lloyd J. Ely** (2) have been named assistant general factory managers.

R. M. Goldhoff (2), who received his M.S. from the University of Cincinnati in August, has assumed the position of research engineer in non-ferrous metallurgy at Battelle Memorial Institute, Columbus.

John J. Naughton (2), associate professor of chemistry at the University of Hawaii, has received an appointment as visiting assistant professor of chemistry at Princeton University for the year 1950-1951.

Charles D. Townsend (2) has established Professional Expediting Service, West Hartford, Conn., which offers technical and engineering aid to small companies.

Following completion of a course for graduate engineers at Algoma Steel Corp., Sault Ste. Marie, Ont., **John Harvey Bradbury** (2) has accepted the position of metallographer and is in charge of the metallographic laboratory at Algoma.

**FOR EXTRA METAL PROTECTION
AND EXTRA PAINT DURABILITY
...USE ACP RUST PROOFING
CHEMICALS AND PROCESSES.**



For over 1/3 of a century, ACP has pioneered in the development, manufacture, sale and servicing of protective metal-working chemicals. These chemicals preserve the metal and the paint finish of both industrial and military products. Write or call for information about ACP Rust Proofing Chemicals and Processes and how they can improve your own products and production quality.

ACP Chemicals Meet Government Specifications

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY
AMBLER, PA.

Manufacturers of METALLURGICAL, AGRICULTURAL and PHARMACEUTICAL CHEMICALS

What's the right X-Ray film?

Product:
Cast part for
vital aircraft
pump

Material:
Aluminum,
2 $\frac{1}{4}$ " thick, 11 $\frac{1}{4}$ "
diameter

Equipment:
150kv x-ray unit



ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE A

With time, money and safety at stake, radiography was used to check this important casting for defects. With moderate kilovoltage to work with, and with aluminum as the material, the radiographer selected Kodak Industrial X-ray Film, Type A.

For with light alloys, this film has enough speed to keep exposures reasonably short even at low voltages. Its high contrast and fine graininess also permit taking full advantage of high kilovoltage machines in detecting irregularities in thick dense materials.

RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and techniques. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price, \$3.



A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. They also provide the means to check welds efficiently and thus extend the use of the welding process.

Type A—has high contrast with time-saving speed for study of light alloys at low voltage and for examining heavy parts at 1000kv. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, under direct exposure or with lead-foil screens. It has extra-fine grain and, though speed is less than in Type A, it is adequate for light alloys at average kilovoltage and for much million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

Radiography... another important function of photography

Kodak
TRADE-MARK

STAINLESS STEEL PLATE

"As Shipped"

by G. O. CARLSON, INC.

LARGE BLANK
TYPE 304;
Size— $2\frac{1}{2}$ " x
 $9\frac{3}{4}$ " x $11\frac{11}{16}$ ";
Hole— $8\frac{1}{2}$ ";
Bend— 22° .



You don't have to buy the "nearest size in stock" from G. O. Carlson, Inc. If you want, we will pattern cut Stainless plate to your individual specifications, or ship you square cut plate to the most economical size for your own shop to cut—either way you save.

Special cutting facilities, plus experienced layout engineers are two important cost saving, time saving elements in the G. O. Carlson, Inc. service in stainless steel plates—backed up by a substantial stock of stainless steel plate in practically all sizes to the largest, and in all analyses.

Send your next inquiry or order to G. O. Carlson, Inc.

CARLSON, INC.

Stainless Steels Exclusively

300 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)
District Sales Offices and Warehouse Distributors in Principal Cities

Stabilized 18-8

(Discussions start on p. 691)
fact that until relatively recently many producers have had difficulty in obtaining carbon contents regularly below 0.10%.

The extending use, however, of the oxygen lance (and to some extent the introduction of improved electrode controls) is making carbon contents of 0.05% or less increasingly common in steel foundry practice. The general availability of such low-carbon steels can in turn render the argument against titanium very much less convincing—if not completely invalid—and it must, necessarily, make the use of both stabilizing agents very much less in quantity and, in some cases, even unnecessary altogether.

J. F. B. JACKSON
Director of Research
British Steel Founders' Assoc.

Melting and Pouring

UNIVERSITY, ALA.

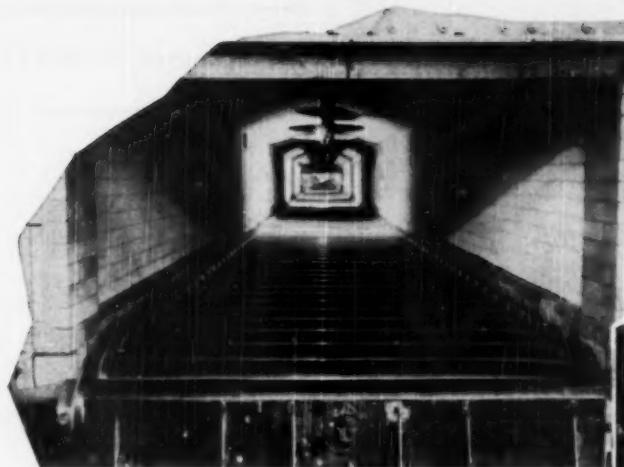
I believe that Mr. Tyrrell's presentation of the comparative merits of columbium and titanium in the fabrication of 18-8 alloys is very concise, and that it also is backed up by a large amount of technical and practical experience. As I was familiar with the titanium-stabilized material in the early stages of its development, it is obvious to many of the old-timers that lack of fabrication and technical skill in the early days of stainless metal had a great deal to do with the unsatisfactory appraisal of titanium.

It is well known that during the past 15 years, thousands of tons of titanium-stabilized alloy has been successfully used in many applications. As Mr. Tyrrell brings out, there is no doubt regarding the great ease of processing the titanium alloy after it has once been melted. One of the chief objections to the titanium-bearing material is the difficulty of melting the alloy as compared to melting the columbium alloy.

E. C. WRIGHT*
Head
Dept. of Metallurgical Engineering
University of Alabama

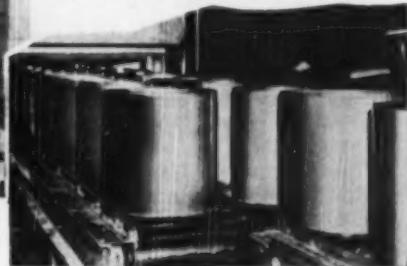
*EDITOR'S NOTE—Mr. Wright was for many years chief metallurgist of Ellwood City (Pa.) plant of National Tube Co.

(Discussions continued on p. 745)



◀ A battery of Inconel conveyor rolls in a brass strip annealing furnace, Scovill Mfg. Co., Waterbury, Conn. The furnace was fabricated by SURFACE COMBUSTION CORP., Toledo, Ohio.

Input end of brass annealing furnace showing coiled brass strip resting on Inconel furnace pans of Scovill Mfg. Co., Waterbury, Conn. These circular pans were fabricated by THE PRESSED STEEL CO., Wilkes-Barre, Pa.



MODERN furnace equipment

in one of world's most MODERN brass mills

Completed in 1949, the new Continuous Strip Mill of Scovill Manufacturing Co., at Waterbury, Conn., is rated as one of the most modern completely integrated brass mills in the world. From the giant continuous slab-casting machinery at one end, to the tractor loaders a quarter of a mile away at the other — every unit operation has been mechanized to the highest degree.

In planning the mill, considerable thought was given to minimizing future maintenance costs. Scovill knew that one source of serious upkeep could be annealing furnace equipment.

So, on the advice of Surface Combustion Corp., and The Pressed Steel Co., annealing furnace pans were made of a metal with a proved record of long life in high-temperature applications . . . INCONEL®. Capable of withstanding temperatures of up to 2000° F., INCONEL promised to give Scovill the long, trouble-free service they wanted.

The conveyor rolls were fabricated from extruded seamless INCONEL tubing. The finished roll dimensions are: 7 in. o.d. with 7/16 in. wall. Effective working width, including end guide collars, is 5 ft. 2 in. The rollers extend through the furnace side walls and are supported by anti-friction, self-aligning bearings.

If you would like to know how — like Scovill — many of the nation's busiest furnace operators are using INCONEL to beat high maintenance costs, write for: *"Keep Operating Costs Down When Temperatures Go Up."*

Remember, too . . . Inco's Technical Service Department is always ready to help you solve high-temperature metal problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



INCONEL . . . for long life at high temperatures

"SPECS" CALL FOR PARTS TO BE TESTED FOR HARDNESS?

Here's the Precision Way to test them!

Brand new contract? Change in plans? Whatever it may be, if "ROCKWELL" hardness is specified—the quickest, easiest, absolutely accurate test for it is with a Wilson "ROCKWELL" Hardness Tester.

The "ROCKWELL" HARDNESS TESTER brings dependable accuracy to your application. It is extremely well made. Easy to use. Test readings are quick and exact. With a "ROCKWELL" Tester, even unskilled help can handle your hardness testing.

WILSON FIELD SERVICE ENGINEERS will study your hardness testing problem and recommend the exact equipment it requires. Assure yourself of the best—SPECIFY WILSON EQUIPMENT—the universal standard of hardness testing.

"ROCKWELL" *Superficial*



HARDNESS TESTER—especially suited for testing thin material, nitrided or lightly carburized steel and areas too small for regular "ROCKWELL" Hardness Tests. Depth of indentation .005" or less. Satisfactory for general testing where surfaces are smooth and materials homogeneous.

TUKON —for micro-indentation hardness testing with either Knoop or 136° Diamond Pyramid Indenter. Made in 3 models to cover the full range of Micro and Macro Hardness testing with loads from 1 to 50,000 grams.



ACCESSORIES

"BRALE" is the only diamond indenter made to Wilson's precision standards. • TEST BLOCKS—enable you to keep your instrument "Laboratory" accurate. • EQUITRON—fixture provides means for accurately positioning test samples. • ADAPTER—permits testing inner cylindrical surfaces with unimpaired accuracy. • WORK SUPPORTS—facilitate testing of variously shaped rod stock, tubing or irregular shapes.

FOR DETAILED INFORMATION WRITE

WILSON MECHANICAL INSTRUMENT CO., INC.
AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

230-F PARK AVENUE, NEW YORK 17, N.Y.



Melting of 18-8 Ti

(Continued from p. 742)

SHEFFIELD, ENGLAND

I am in almost complete agreement with Mr. Tyrrell's conclusions; my only real objection to the use of titanium as a stabilizer instead of columbium in austenitic chromium-nickel stainless steels is in connection with highly polished sheets. A mirror finish is frequently demanded and it must be admitted that titanium-stabilized steel sheets do not yield such satisfactory results as those produced from columbium-stabilized steels. Where this high degree of surface finish is not required, however, the titanium-bearing steels are in all other respects quite equal in quality and general properties to those stabilized with columbium, and this applies particularly to steel castings, many thousands of which have been produced by my own company.

Our melting units comprise both high-frequency and electric-arc furnaces, the former being employed in the manufacture of stainless steel castings and the latter for the production of ingots.

Induction Melting—The titanium is added as ferrotitanium in the furnace and we use the 40% Ti grade and not the 20 to 25% Ti grade, since a lesser amount is needed and the bath is not chilled so much. The alloy should be added in lump form as the fine stuff gets entrapped in the slag, which should be thinned by the addition of some form of calcium alloy (Ca-Si or Ca-Si-Mn) at the same time as the titanium addition. The heat generated from the oxidation of the calcium together with the thin slag formed assists the lump ferrotitanium to sink into and dissolve in the molten metal. *Before* the titanium addition is made the temperature of the bath should be raised to that finally required, as it is essential to pour from the furnace *immediately* after the alloy has disappeared into the melt.

Loss of titanium in the ladle becomes serious only when making very small castings (*a*) because of the degree of superheat necessary, (*b*) by virtue of the time factor involved in shanking small castings and (*c*) the actual use of "open" shanks. Therefore, when small castings are being made, a surplus of titanium must be added over and

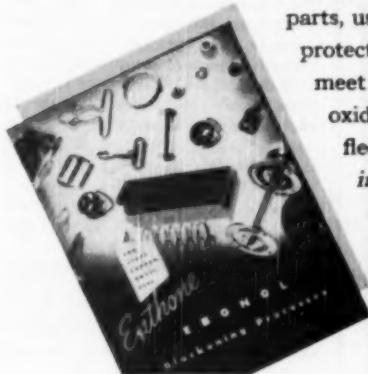
(Continued on p. 746)



GUN AND PISTOL PARTS COURTESY HIGH STANDARD MANUFACTURING CORP.

Millions of Guns... ammunition shells,

cartridge clips, shoe eyelets, buckles, buttons, harness hardware, radar parts, used in World War II, received these government-approved, protective black finishes. Enthone Ebonol blackening processes meet today's Army, Navy and Air Force specifications for black oxide coatings on steel, copper, brass and zinc . . . for wear, reflectivity, saltspray, and weathering. NEW EBONOL Booklet *including detailed operating instructions, sent free on request.* U.S. Patents — 2,364,993, 2,460,896, 2,460,898, 2,481,854. Canada, 463,852.



Enthone inc

442 ELM STREET NEW HAVEN CONN

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. FLATS, HEXAGONS, SQUARES, ROUND



Get your
STANDARD ALLOY STEEL
from the same reliable source
as **HY-TEN ALLOY STEEL**



Although perhaps best known for our *special HY-TEN Alloy Steels*, Wheelock, Lovejoy carries a full line of *standard steels in stock* for fast, dependable service from our warehouses. These standard grades include: C-1117, A4615, E4617, A4620, A4140, A4142, A4145, A4150, A4340, etc.

There are many advantages in using a single source for all your alloy steel needs, and Wheelock, Lovejoy offers these extra services—modern heat treating, testing and cutting, plus prompt delivery of blocks, rings, spindles and other forged shapes to your exact specifications.

Call in your nearest Wheelock, Lovejoy metallurgical expert—he represents a firm that is backed by over a century of experience in the use and application of fine steels.

WL steels are metallurgically constant. This guarantees uniformity of chemistry, grain size, hardenability—thus eliminating costly changes in heat treating specifications.

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

134 Sidney St., Cambridge 39, Mass.
and Cleveland • Chicago • Detroit
Hillside, N. J. • Buffalo • Cincinnati



WHEELOCK, LOVEJOY & CO., INC. • WAREHOUSE SERVICE • IN CANADA • HY-TEN AND RISI

CAMBRIDGE • CLEVELAND
CHICAGO • HILLSIDE, N. J.
DETROIT • BUFFALO
CINCINNATI

In Canada

SANDERSON NEWFIELD, LTD., MONTREAL

Melting of 18-8 Ti

(Discussions start on p. 691)
above the theoretical amount that would be regarded as sufficient for the much larger ingots teemed through a ladle nozzle.

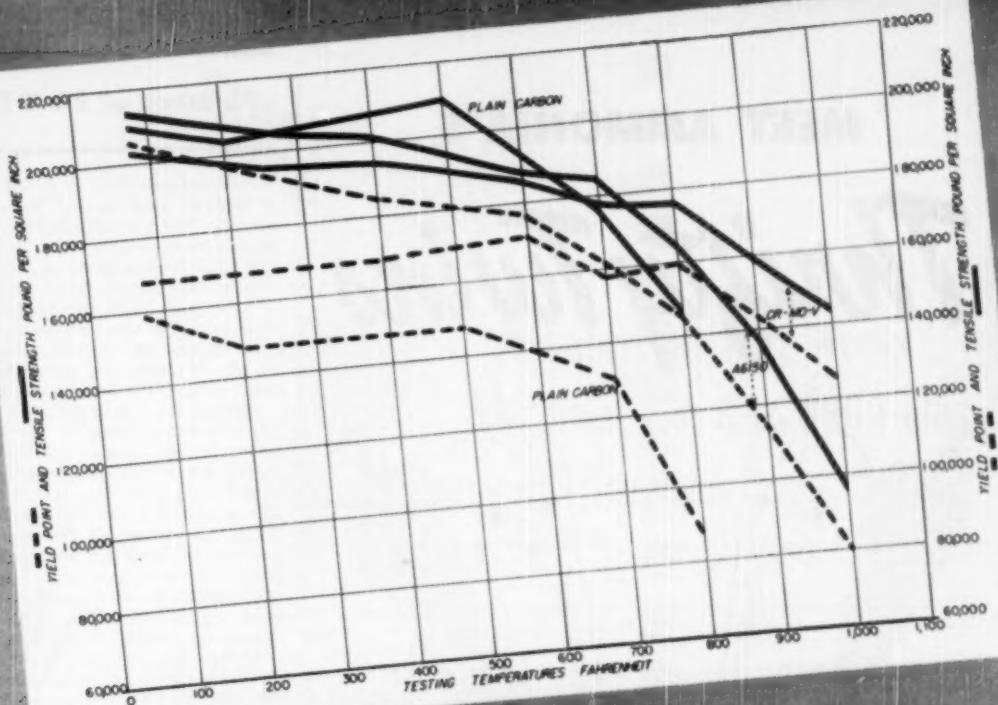
The recovery from titanium-bearing scrap is practically *nil*. That from ferrotitanium varies with melting practice. To minimize titanium losses or, rather, to obtain a more or less constant loss value, the melt should contain about 1% each of silicon and manganese, and be deoxidized by some powerful deoxidant before the titanium is added. Use of a Ca-Si-Mn alloy for such deoxidation appears to improve the fluidity of stainless steels of the austenitic type. Generally, we recommend the addition of 0.8% titanium to the melt to retain 0.4% in the solid steel, that is, there is a loss of 50% of the titanium, but the percentage loss becomes less with higher initial titanium additions, as would be expected.

Titanium does not appear to have much influence on the fluidity of the steel at the high temperatures needed for the successful running of steel castings and, as mentioned, we always aim to keep the silicon and manganese around 1% each.

As regards surface quality of the castings, no unduly large patches of slag are encountered if the slag is held back by a skimmer during pouring. As regards suitability for use, our experience is that titanium-stabilized steels are just as resistant to attack as columbium-stabilized steels and, indeed, under certain conditions are perhaps better.

Basic Electric-Arc Melting—In our early experiments concerning the production of ingots from steel melted in the basic electric-arc furnace (4½ tons capacity), exceptionally high and completely uncontrollable losses of titanium resulted from adding the ferrotitanium in the furnace. Consequently, we developed a simple method of making the addition during the pouring of the steel into the ladle. A hopper mounted on a frame, which straddles the furnace pit, is now used. A lever arrangement permits the opening of a ball valve and through the aperture at the bottom of the hopper a constant flow of the ferrotitanium (½-in. mesh, 40% Ti grade) occurs, in alignment with the stream

(Continued on p. 748)



HIGH TEMPERATURE PROPERTIES of Cr-V and Cr-Mo-V Spring Steels

SPRINGS FOR SERVICE at elevated temperatures require steels which resist softening and lowering of the yield point. Unless hardness and yield strength are stabilized by correct alloy additions to the steel, these properties deteriorate rapidly as the temperature is raised.

The chart above shows the yield point and tensile strength of three types of spring steel at elevated temperatures determined by standard short-time tension tests.

Springs of plain carbon steel are sometimes used at moderately elevated temperatures, although their lower yield values prevent them from giving service as satisfactory as that of the alloy spring steels.

Chromium-vanadium steel springs, such as AISI 6150, give better service at ordinary temperatures because of the higher yield point. In addition, they may be used at operating temperatures up to about 700° or 750° F

because they retain high yield point values as the temperature is increased.

Chromium-molybdenum-vanadium steel was especially designed for springs operating at temperatures in excess of 750° F. It can be used for springs operating at temperatures as high as 850° F or even higher under some conditions. At 800° F, the yield point of this steel is still greater than that of plain carbon steel at room temperature.

If you have a problem in spring applications at elevated temperatures, our metallurgical engineers will be glad to help you solve it.

MAKERS OF
ALLOYS



CHEMICALS
AND METALS

VANADIUM CORPORATION OF AMERICA

420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • DETROIT • CHICAGO • CLEVELAND • PITTSBURGH

MEET AMMONIA'S

Thrifty Twins



FROM DISSOCIATED AMMONIA

Each cylinder or tank car of Barrett Standard Anhydrous Ammonia (REFRIGERATION GRADE) is a low-cost source of two gases—HYDROGEN and NITROGEN. When dissociated, one pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

You save money by using dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices.

Anhydrous ammonia also has unsurpassed qualities in the nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and assistance of Barrett technical men are readily available. For information, contact Barrett, *America's leading distributor of ammonia*.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET, NEW YORK 6, N. Y.

*Reg. U. S. Pat. Off.



Melting of 18-8 Ti

(Discussions start on p. 691)

of molten metal issuing from the furnace. The two streams thus mix as they flow into the ladle. A slag-trap door is in position in the furnace so that practically all the slag is held back until the hopper is empty; in this way, minimum titanium is lost in the slag. Subsequently, of course, slag flows into the ladle to give the desired covering.

Adding the equivalent of say 0.60% titanium, between 0.30 and 0.40% of the element can be expected in the solid steel, that is, the actual yield may vary from 50 to 66% according to the bath condition at the time of tapping. No titanium recovery is possible from titanium-bearing scrap. There is no appreciable variation in titanium content from ingot to ingot in casting ten ingots each weighing 1000 lb.

Before the steel is poured into the ladle, the bath temperature is raised to 2970° F. in order to compensate for the cooling effect (about 100° F.) of the titanium addition. At normal ingot pouring temperatures, the titanium-bearing austenitic steels made from virgin materials appear to be somewhat more viscous than similar steels free from titanium, but this decrease in fluidity has not been evident in the many heats we have produced from 100% stainless steel scrap charges involving the use of the oxygen lance. Our usual procedure is to teem our ingots through a 1 1/4-in. nozzle ladle into a tun-dish also having a 1 1/4-in. nozzle.

All our titanium-stabilized stainless steel from the electric-arc furnace has been rolled into bar, sheet and strip which, in most instances, has been subject to A.I.D. inspection. Complaints have been few and since the employment of our oxygen technique almost nonexistent.

Provided that the carbon content is sufficiently low and the titanium not greatly in excess of that needed for stabilization, excellent results are obtained and the steel is definitely as good as that stabilized with columbium. By using the oxygen lance and starting with 100% stainless steel scrap charges, we regularly produce steels of less than 0.05% carbon, which results in a superior quality material when stabilized with titanium.

EDWIN GREGORY

Director

Edgar Allen & Co., Ltd.

(Discussions continued on p. 750)



A Lubricant that Works from sub 0 to 3000 plus

ORDINARY lubricants gum up at extremely low temperatures or break down at extremely high temperatures . . . but not Acheson's specially processed "dag" colloidal graphite!

This versatile material is dispersed in organic and inorganic carriers for positive transmission to the zone of lubrication . . . for effective concentration at those points . . . for friction-fighting that can't be beat!

"dag" colloidal graphite is unique in its combination of properties and uses. It is very slippery and extremely durable, anti-corrosive, gas adsorbent, chemically inert and, of course, highly resistant to heat.

In deep piercing you get smooth forgings, close tolerances and reduced wear on dies. In casting and mold stripping you get smooth surfaces, clean parting, fewer rejects; and additional mold life.

In forging you minimize scaling and sticking, improve finish, lengthen die life.

In stretch-forming you reduce tearing and rippling. In wire-drawing you get uniform diameter, better finish and greatly extended die life.

Brass, bronze, aluminum, magnesium, carbon steel and stainless steel . . . wherever your fabrication problems are friction and heat . . . "dag" colloidal graphite reduces the one and resists the other.

The NEW Acheson Bulletin #426 on the Use of "dag" Colloidal Graphite in Metalworking operations is just off the press . . . a copy is ready for you if you will fill in and mail the coupon.



ACHESON COLLOIDS CORPORATION
Port Huron, Michigan

Send me the NEW
Metalworking Bulletin #426

Send an Acheson
engineer

NAME _____

COMPANY _____

STREET _____

CITY _____

ZONE _____

STATE _____

L10

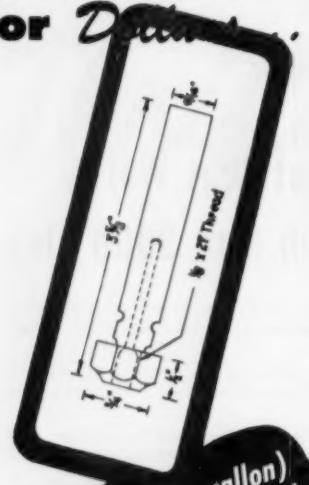
Acheson Colloids is equipped
to do custom disintegrating,
dispersing, and stabilizing
of solids in a wide variety
of vehicles. If you are in
need of this type of service,
tell us about it. We may be
able to help you.

dag
DISPERSIONS

Acheson Colloids Corporation, Port Huron, Michigan

... also Acheson Colloids Limited, London, England

How to trade Pennies for Dollars



10c more (per gallon)
invested in cutting fluids
**SAVES \$50 PER DAY
PER MACHINE!**

PRICE alone makes no profit. The drawing above illustrates a shackle bolt which is drilled and tapped on a New Britain Automatic. Using an inferior cutting oil 12 taps were used up every $2\frac{1}{2}$ days—12 pieces per tap. A change to Stuart's SPEEDKUT M on a $2\frac{1}{2}$ day run showed 530 pieces per tap—no taps used up. The saving? Taking into full account the pennies—higher price of Stuart quality oil: \$50 per day per machine!

If you are interested in a saving like this, ask to have a Stuart representative call. There is no obligation—we'll let Stuart performance do the selling.

*Send for your copy of
"CUTTING FLUID FACTS"
Stuart's booklet of
cutting fluid data.*

D.A. Stuart Oil co.

2743 S. Troy Street, Chicago 23, Illinois

Low-Carbon 18-8

(Discussions start on p. 691)

Lower Carbon Contents

BALTIMORE

The conservation of columbium, which Mr. Tyrrell has so ably discussed, is of special interest in view of the likely large increase in demand for this element for military purposes. For applications of the type described, involving exposure to hot exhaust gases up to 1500° F., there seems to be no reason why Type 321 titanium-stabilized steel cannot replace the columbium-bearing Type 347.

It has been pointed out that for inert-gas-shielded arc welding, Type 321 is superior to Type 347 because of its lesser tendency to develop "hot short" cracks. This may be explained on the basis of the difference in composition balance of the two alloys, which is such, on the average, that Type 321 weld deposits will contain some delta ferrite, while Type 347 deposits will not. The presence of this phase in austenitic welds is known to inhibit their normal tendency to "hot short" cracking. (For further information the reader may refer to the article by R. David Thomas, Jr., in *Metals Progress* for September 1946.)

The difference in forming characteristics can be attributed in part to the fact that since columbium forms a more insoluble carbide than titanium, annealed Type 347 generally has more undissolved carbides in the matrix than Type 321, which makes it slightly stiffer. This is evident in the slightly higher average tensile and yield strengths shown for annealed Type 347 in various publications.

Another way of conserving columbium which is not mentioned in Mr. Tyrrell's article is through the use of the extra-low-carbon (0.03% max.) alloys. These have been available commercially for several years and have proven themselves especially useful in applications such as welded vessels and other articles used in the chemical industry involving short exposure in the range of carbide-precipitation temperatures. For applications where service temperatures do not exceed 800°F., Types 304 ELC, 316 ELC and 317 ELC may be used without fear of weld decay, as their low carbon content will prevent harmful carbide formation.

(Continued on p. 752)

YOUR HARDNESS TESTER . . .

**IS ONLY AS
GOOD AS THE
DIAMOND IT
USES**



Standard "C" Diamond Cone
\$18.00 F.O.B. Detroit

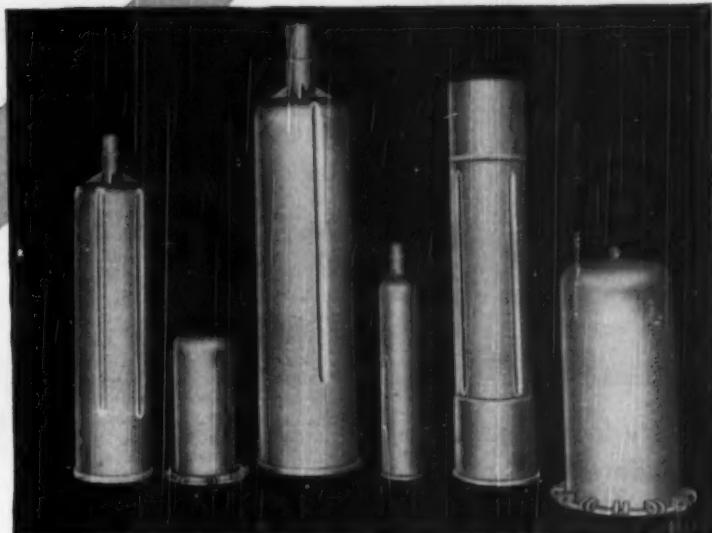
Dependably accurate "Rockwell" testing results are obtained only when every part of your hardness testing equipment is made to precision limits. That is why a correctly designed diamond penetrator is of such great importance. Always specify CLARK Diamond Cone Penetrators, both for Standard and for Superficial "Rockwell" testing. They are accurately made to the proper size and shape; exactly formed by expert lappers. CLARK Penetrators are designed for use on all "Rockwell" type testing machines.

CLARK
TOMORROW'S ACCURACY TODAY

INSTRUMENT, INC.

10900 FORD ROAD
DEARBORN, MICH.

How long should a Retort last?



3600 hrs.?. . . 80,000 hrs.?

Let's be honest. We could claim that our retorts last 80,000 hours. Some have. We could claim they last 10,000 or 12,000 hours. Many have.

We have also had some go out of service after 3600 hours. But even so, Thermalloy* had outlasted—for that particular service—most previously used retorts.

The point is, there are too many variables in methods of operation and maintenance for us or any other manufacturer to make general claims on retort life. These factors include: cycle of heating (batch or continuous) . . . method

of heating (radiant or direct-fired) . . . frequency of charging . . . operative temperatures . . . type of suspension or support . . . efficiency of maintenance.

This we can say! In *comparable* service, Thermalloy retorts and muffles have attained an outstanding record for "more operating hours per dollar."

For recommendations on your particular installation, contact your nearest Electro-Alloys office, or write Electro-Alloys Division, 1982 Taylor Street, Elyria, Ohio.

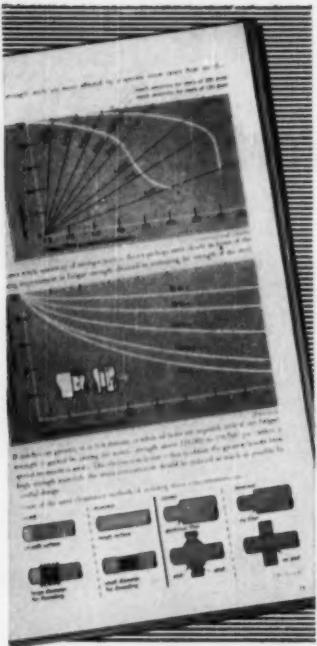
*Reg. U. S. Pat. Off.

Specify CHEMALLOY* for corrosion resistance . . . THERMALLOY* for heat and abrasion resistance

Write for Technical Booklet—Cast 16% Cr.—33% Ni Alloys

AMERICAN
Brake Shoe
COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO



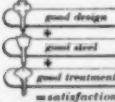
Every designer must be something of a metallurgist

Here are 72 pages packed with information of vital significance to engineers faced with the design, selection and treatment of steel components to give a specified service at minimum cost.

Besides dealing with scientific design, the book gives important metallurgical data, all compiled from the designer's viewpoint. Free on request.

Climax Molybdenum Company

500 Fifth Avenue - New York City



Please send your
FREE BOOKLET
3 KEYS TO SATISFACTION

Name _____

Position _____

Company _____

Address _____

MP-11

© F22

Low-Carbon 18-8

(Discussions start on p. 691) hide precipitation during the short heating period used in welding. Laboratory tests in extremely corrosive mediums have shown that the low-carbon stainless steels are equal to their columbium-stabilized counterparts in the as-welded condition and this has been confirmed in practical field experience (A.S.T.M. Special Technical Publication No. 93, 1950, p. 56-80, 87-100). The mechanical properties of these alloys up to 800° F. are similar to those of Types 304 and 316, being slightly lower with the lower carbon content. The low-carbon alloys are readily formed and may be satisfactorily welded either by resistance or by all types of shielded-arc welding with metal electrodes. The addition of these alloys to the roster of stainless steels, together with a much improved knowledge of manufacturing and fabricating Type 321, should go a long way toward relieving the drain on our columbium resources.

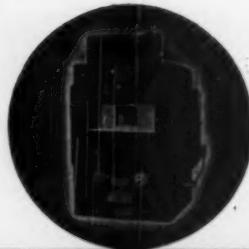
F. K. BLOOM
Supervising Metallurgist
Research Laboratories
Armco Steel Corp.

Welded Tubing

UNION, N. J.

It is agreed here that the conservation of columbium is a worthwhile endeavor. However, many of us believe that the subject should be discussed on a broader basis than was attempted by Mr. Tyrrell, who understandably limited his paper to suitability of the two most common types of stabilized steel for aircraft applications. The broader discussion that we have in mind would include consideration of the following alloys in addition to Types 321 and 347: (a) the recently developed steels with carbon contents of 0.03% max., (b) columbium-stabilized steels with carbon contents greater than 0.03% but lower than in the current production of Type 347, (c) steels stabilized with columbium contents of eight times the carbon content — as widely used during World War II — instead of the usual ten times, and (d) tantalum-columbium steels.

As manufacturers of welded tubing, we had a special dispensation during the last war to use Type 347 exclusively, even though 321 might have been specified. At that time, (Continued on p. 754)



BURRELL BOX and MUFFLE FURNACES

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC BOX and MUFFLE FURNACES for melting, sintering, heat treating, ignitions, etc.

Write for Bulletins 315 and 515.



1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA



BURRELL TUBE FURNACE

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC TUBE FURNACES for determination of carbon or sulfur by combustion and for experimental or production purposes.

Write for bulletin 310.



1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA



From the batch type installation at the left martempering base detonator fuses, to the huge mechanized furnaces austempering automobile bumpers illustrated below, Ajax Electric Salt Bath Furnaces are replacing old-style quench and temper methods for a wide variety of steel products.



From ring gears to plow points...
From bearing races to cast iron cylinder sleeves...
From uniformly shaped metal parts to odd and irregular sizes...

Scores of installations have proved the tremendous possibilities for economy, greater speed and efficiency in martempering and austempering, because all water and oil quenches are eliminated.

Distortion is so negligible that parts can be machine finished *before* hardening. Final grinding is eliminated or materially reduced. Scale, decarb and quench cracks are eliminated. Toughness and ductility are increased. The work is done materially faster—in less floor space—with lower labor costs. Let the Ajax Metallurgical Service Laboratory prove these claims on a specimen batch of your actual parts, under actual working conditions.

Write for Ajax Bulletin 120

AJAX ELECTRIC COMPANY, INC.
910 Frankford Avenue

Philadelphia 23, Penna.

World's largest manufacturer of electric heat treating furnaces exclusively

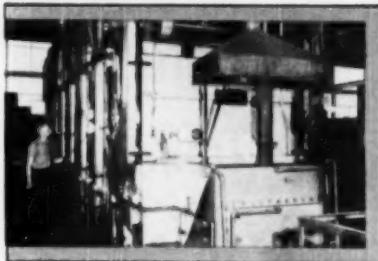


AJAX 
ELECTRIC SALT BATH FURNACES



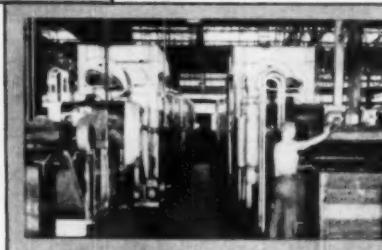
**...Because
critical parts are heat treated
in HOLCROFT furnaces**

Caterpillar Tractor Co.—producer of rugged, long-lasting earthmovers—adds another life to the cat's proverbial nine! This new model will last longer because certain critical parts are hardened and drawn in Holcroft furnaces. Result: extra stamina for the product and lower costs for the owner. Plant savings are possible because of high production, fast operations and fewer rejects.



This is the discharge end of one of two Holcroft hardening furnaces in the "Caterpillar" plant. It is radiant-tube-fired, completely conveyorized, and has a capacity of 3000 lbs. per hour.

This is the unloading end of the twin draw furnaces. They are also conveyorized, using alloy roller chains. The furnace is heated by gas-fired recirculating heaters.



Holcroft installations can cut costs, improve products.
Write today for information.

BLAZING THE HEAT-TREAT TRAIL



Stainless Tubing

(Discussions start on p. 691)
this mill and many similar mills were using the atomic hydrogen arc-welding process, with which the manufacture of Type 321 tubing was a hazardous and difficult undertaking, especially in gages heavier than 0.049 in. The defects that developed when Type 321 was welded with atomic hydrogen equipment were not those described by Mr. Tyrrell for Type 347, but they were serious enough so that the risk in welding was not worth the effort required to overcome it. Since that time, most manufacturers of welded tubing have installed some adaptation of inert-arc welding, and subsequent experience has shown that 321 is much less hazardous to weld than 347, for the reasons described by Mr. Tyrrell.

If the adoption of Type 321 becomes more widespread we can expect some problems involving the difficulty of final heat treatment for adequate stabilization, welding as it relates to a stabilized end product, and seams that occur as a result of stringers of titanium or titanium compound and their effect on the ductility of manipulated parts.

J. A. DEITRICH
Manager, Alloy Tube Division
The Carpenter Steel Co.

More on Welded Tubing

CLEVELAND

The statements in Mr. Tyrrell's article comparing the welding characteristics of the two alloys, 321 and 347, are of particular interest to us as producers of welded tubing. A continuous automatic process is always used for welded tubing but the welding operation itself has changed over the years. During this period, the major percentage of production has been confined to 347, with the production of 321 limited to trial lots or small quantities.

The first welding process to be applied to stainless tubing was resistance welding, and we found no appreciable difference in welding speeds and technique or weld quality between the two steels. Acetylene welding was also used with apparently equal ease on the two alloys.

With the trend to arc fusion welding, a definite difference in welding characteristics was found.

(Continued on p. 756)

News . . . about The Production of NODULAR CAST IRONS with CERIUM

New booklet describes in detail
actual foundry methods as practiced
by members of the British Cast Iron
Research Association.

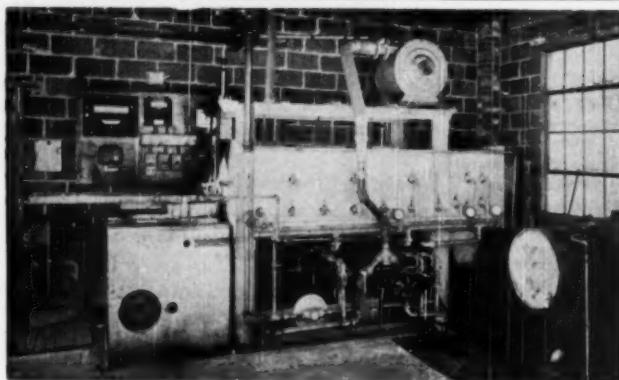
For the first time, available in the
United States.

Sent upon request.

CERIUM METALS Corporation

*Pioneer and Largest Producer
Cerium and Cerium Alloys*

153 WAVERLY PLACE • NEW YORK 14, N.Y.



RECIPROCATING, CONTROLLED ATMOSPHERE FURNACES SUITED TO WIDE RANGE OF GENERAL AND ATMOSPHERE WORK

VERSATILE. A.G.F. Reciprocating Furnaces are suited to continuous clean hardening, annealing, normalizing, case-hardening by the patented Ni-Carb process, etc. Work treated in the same furnace may range from extremely small light springs, stampings, drop forgings, etc., up to quite large and heavy pieces.

THE RECIPROCATING MUFFLE advances work through the heat by its own momentum. Heat losses and maintenance problems are reduced to a minimum by the complete elimination of conveying mechanism from the heating chamber. There is no traveling belt to be alternately heated and cooled — only work enters and leaves the furnace.

Write for Bulletin 815-AB today.

AMERICAN GAS FURNACE CO.
1002 LAFAYETTE ST., ELIZABETH 4, N.J.



Stainless Tubing

(Discussions start on p. 691) depending on the specific process used for the automatic continuous welding of the various types of stainless tubing. Early experience was based on atomic hydrogen welding, and it was found necessary to discontinue the use of this process on Type 321 because of the excessive number of gas pockets and pits formed in the welding operation. This process was used extensively for 347 tubing and considerable footage was produced before and during the war years in a wide range of sizes. Repair welding is not normally done on welded tubing; consequently scrap losses were excessively high on Type 321, making it uneconomical to produce welded tubing in this analysis.

We have subsequently installed inert-gas arc welding as a replacement for atomic hydrogen welding. Major production has been confined to Type 347, and increased welding speeds, as compared with atomic hydrogen welding, have been possible on this alloy. There has been very little footage made in Type 321, as the demand appears to be wholly for 347, probably because 321 was heretofore not readily available in welded tubing. Experimental runs on 321 indicate that weld quality with inert-gas welding should be equivalent to that produced in 347. Welding conditions applicable to the two alloys are practically identical, with no difference in welding speed or control of the operation.

Because of the definite shortage of columbium and the lower cost of the titanium steel, we anticipate a trend to 321 in welded tubing for applications where heat resistance and freedom from carbides are the primary considerations. The use of inert-gas arc welding should promote the use of 321 tubing as a replacement for 347 tubing.

J. S. ADELSON
Chief Metallurgist
Steel and Tubes Div.
Republic Steel Corp.

Seamless and Welded Tubes in Britain

BIRMINGHAM, ENGLAND

In the manufacture of tubes we find no very significant differences between the two types of stabilized stainless steel. Seamless tubes in (Continued on p. 758)



The Road to Tomorrow

In these troubled times, no one can safely forecast what tomorrow will bring. The road ahead may be steep and difficult, demanding courage and ingenuity to conquer the peaks that block the path.

At Wisconsin Steel, we are doing our very

best to serve our customers. Our capacity is strained to the limit and still we cannot produce enough quality steel to meet demands. But we will continue to stress quality and to improve our products. We believe that is the way to overcome the obstacles on the road to tomorrow.



**WISCONSIN STEEL COMPANY, Affiliate of
INTERNATIONAL HARVESTER COMPANY**
180 North Michigan Avenue • Chicago 1, Illinois

WISCONSIN STEEL

November, 1950; Page 757

Specify THE JACO

PROJECTION COMPARATOR MICROPHOTOMETER

for { SPEED
ACCURACY

No longer must the practical spectrographer be uncertain as to the line he is actually reading. There is the line—in plain, full view—**WHILE IT IS ACTUALLY BEING SCANNED.** This is only one of the many features of this precision instrument.



- Improved Resolution
- Greater Certainty
- A Wider Density Range
- Increased Comfort
- High Speed
- A Wide Field of View
- Precise Linear Measurement

*Write for
Catalog No. 1-4
and a list of purchasers*

JARRELL-ASH CO.

165 NEWBERRY ST.

BOSTON 16, MASS.

**Hardness and Case Depth
ANYWHERE YOU NEED IT!
with Flame Hardening**

Our Services:

Fuse-Nitriding, Electronic Induction Hardening, Flame Hardening, Heat Treating, Bar Stock Treatment and Straightening (all lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocarbon, Charnamizing, Cyaniding, Sand Blasting, Tensile and Bend Tests.

*Approved Steel Treating Equipment by U.S. Air Force—Serial No. DE-S-24-1 through 30.

LONGER LIFE FOR LOW COST STEEL

Your original equipment will cost less and last longer if you let Lakeside flame harden points of wear. Complete and selective flame hardening of the highest quality is available. All four methods—vertical progressive, rotary progressive, spinning and combination. Whether your problem involves increasing the life and efficiency of large equipment or the economical production of small parts, Lakeside has the answer!

THE Lakeside Steel Improvement Co.
5418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

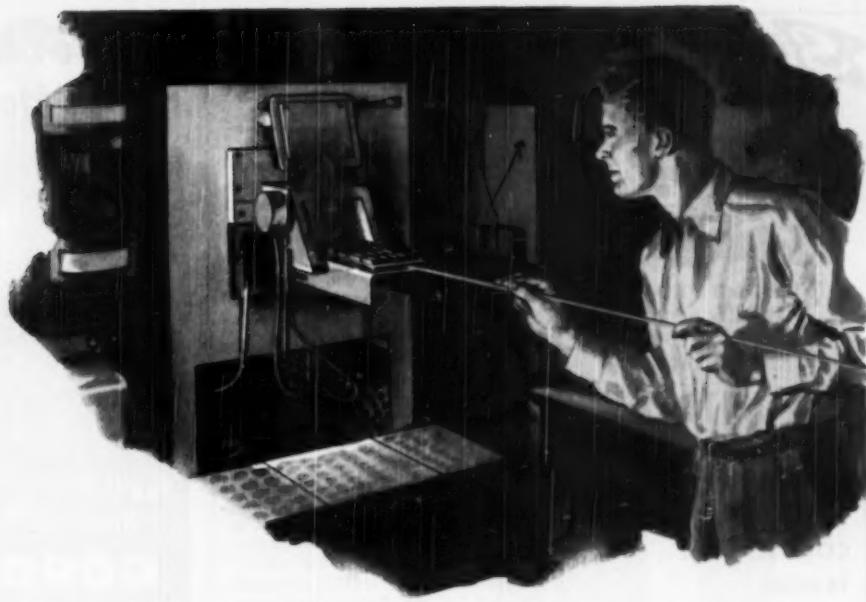
Stainless Tubing

(Discussions start on p. 691)
these materials are made here by hot extrusion and cold drawing, and for compositions otherwise similar we find that Types 321 and 347 can be treated alike as regards hot and cold working operations; they give the same mechanical properties in comparable finished conditions. Techniques developed originally for the titanium-stabilized steel are applied without change to the columbium-stabilized variety. Type 321 steels sometimes contain nonmetallic inclusions that make polishing more difficult and we have on occasion found it easier to get a good mirror finish with Type 347, but this is not very often the determining factor in the choice of material.

Welded tubes are made from strip by the atomic hydrogen process in both classes of steel; more correctly, the demand for the welded tube in Type 347 is small and our experience is confined to some thousands of feet made on an experimental basis. We found that the two steels could be treated alike as regards welding speed, and that welded tubes could be subsequently cold drawn with equal facility to give the same mechanical properties in the softened condition or in the as-drawn condition after comparable amounts of reduction. In that relatively limited experience we had the impression that the columbium-stabilized steel formed a more fluid pool under the arc, and that the finished welds looked rather smoother, but we do not know whether that is generally true. In atomic hydrogen welding we did not observe the differences mentioned by Mr. Tyrrell in connection with inert-gas welding, although we interpret that section of his paper to mean that he recognizes that those differences may be due to variations in composition other than the simple presence of the one stabilizing element or the other.

Altogether, therefore, our experience indicates that Types 321 and 347 are alike as far as tube manufacture is concerned, and that the choice is a matter of initial cost, availability, and of serviceability in conditions peculiar to final use.

J. W. JENKIN
General Manager
Dept. of Development & Research
Tube Investments, Ltd.
(Discussions continued on p. 760)



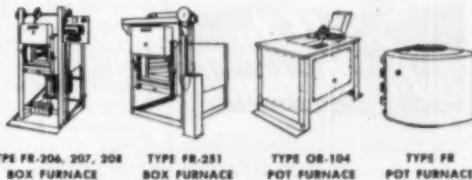
**Dependable performance
year after year with
Hoskins Chromel -equipped Electric Furnaces**

There's nothing revolutionary about Hoskins Furnaces, but you'll find them hard to beat when it comes to delivering useful electric heat. And for good reason, too. Because every Hoskins Electric Furnace is equipped with durable CHROMEL heating elements. Long-lasting elements that possess close-to-constant "hot" resistance between 700° and 2000°F., that deliver full-rated power throughout their long and useful life. Dependable heating elements designed to give you uniform distribution of heat with maximum operating efficiency. Important, too, every CHROMEL element in every Hoskins furnace is formed in such a way as to permit quick and easy replacement.

Take the Hoskins FK Braze Furnace illustrated above, for example. Compactly designed for

brazing small tools and parts, it's economical to operate... low in hydrogen and power consumption, quick on recovery. And it's equipped with heavy-duty reverse "U" type heating units made of long-lasting 1" by $\frac{1}{16}$ " CHROMEL-A ribbon.

So next time you're in need of good dependable heating equipment, get the facts on Hoskins CHROMEL-equipped electric furnaces. Our Catalog-59R describes the line... want a copy?



HOSKINS MANUFACTURING COMPANY

4445 LAWTON AVE. • DETROIT 8, MICHIGAN

NEW YORK • CLEVELAND

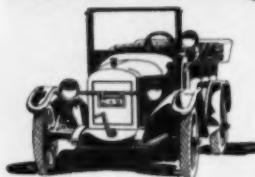
• CHICAGO

West Coast Representatives in Seattle, San Francisco, Los Angeles
In Canada: Walker Metal Products, Ltd., Walkerville, Ontario

*the

nickel-chromium resistance alloy that first made electrical heating practical

Since 1914



A TRIED and PROVEN
SOURCE FOR

TESTING MACHINES

BRINELL
DUCTILITY
COMPRESSION
TENSILE
UNIVERSAL
TRANSVERSE
HYDROSTATIC
PROVING INSTRUMENTS

and

Special Testing Machines built
to your Specifications.

Send for
this
Brochure



Steel City
Testing Machines Inc.

8835 Livernois • Detroit 4, Mich.

Without obligation send me your brochure
on testing instruments. Also special folders on
following types (check your interest):

<input type="checkbox"/> Brinell Hardness	<input type="checkbox"/> Ductility
<input type="checkbox"/> Compression	<input type="checkbox"/> Tensile
<input type="checkbox"/> Transverse	<input type="checkbox"/> Hydrostatic
<input type="checkbox"/> Proving Instruments	

NAME

TITLE

Attach coupon to your letterhead
and mail

Stabilized 18-8

(Discussions start on p. 691)

Further British Experience

SHEFFIELD, ENGLAND

Although in the development of stabilized austenitic stainless steels in Britain additions of many elements were proposed and tried, the type became essentially a titanium-bearing steel, to the exclusion of practically all other of the variously proposed additions. Columbium did not feature in the earlier attempts to obtain a steel immune from intergranular attack.

The earliest aircraft specifications for this type of material, for example, DTD 171 (Nov. 1931), although including a bend test on a sample boiled in the copper sulphate-sulphuric acid solution after reheating for 30 min. at 1200° F., included titanium in the list of additional elements which may be present at the option of the steelmaker, but it did not include columbium, nor did a re-issue of the specification (Nov. 1932). It was not until a further issue in Oct. 1941 (DTD 171B) that columbium was included.

It can be taken, therefore, that there is considerable and extended experience with titanium-stabilized steels in Britain and that very large quantities have been successfully used in aircraft, chemical, textile and kindred industries.

In the American Types 321 and 347 the carbon content is limited to 0.08% and the addition of the metals titanium and columbium respectively are related numerically to the carbon content. In general the British specifications do not restrict the carbon content to such low values; for example, the Air Ministry specifications allow 0.2% max. and the British Standard "En Series" limits the carbon content to 0.15% max. for En 58-B, C, F and G, of which B and C contain titanium and F and G columbium. Both specification authorities require that the respective materials shall satisfy the boiling copper sulphate-sulphuric acid test and both also specify a proportionate addition of the stabilizing element. There are slight differences in the proportions of the stabilizing elements now required by the different specifications.

At the works where the writer is engaged, experience shows that the melting loss of titanium is not

(Continued on p. 762)

Correct Furnace Atmosphere



You'll Always
Know with a

GORDON
Furnace Atmosphere
Indicator

Do you depend upon badly scaled or de-carburized work to tell you that something has happened to your furnace atmosphere? And then spoil more work getting the atmosphere back to where it belongs?

A Gordon Furnace Atmosphere Indicator will watch that for you. It makes a continuous, thorough check of the furnace atmosphere, and as soon as it changes, the change is detected and indicated so that quick necessary adjustment can be made. It works on gas or oil-fired furnaces and in protective atmospheres on electric furnaces.

The Gordon Furnace Atmosphere Indicator works on the principle of the relative thermal conductivity of gases. It is so simple and easy to use that top results can be obtained with shop or non-technical personnel.

Where a continuous record of atmosphere readings is required, the indicator can be co-ordinated with a recorder.

You can't afford to be without this instrument any longer.

Price, complete with U-tube \$335.00
and Sample Filter, 110 V, 60 C.

Write for descriptive bulletin
for full information.

GORDON
Furnace Atmosphere
Indicator

CLAUD S. GORDON CO.

Specialists for 36 years in the Heat-Treating
and Temperature Control Field

Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.

Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

We are Specialists in BIG CASTINGS for the Heat-Treating Field

The efficiency and reliability of Driver-Harris casting procedures are in evidence in hundreds of plants throughout the country, where retorts of cast Nichrome* and Chromax*—ranging up to 5000 pounds in weight—are giving dependable service day in and day out.

Our advanced welding techniques enable us to produce high performance muffles of virtually any length desired. For example, Nichrome muffles almost 70 feet in length, composed of cast sections welded together, are performing as effectively as conventional size units cast in one piece. And our shaker hearth muffles, with bottom plate machined to specifications and top plate welded in position, are giving outstanding service over remarkably long periods of operation.

The comparatively high rate of heat transfer of thin-walled Nichrome and Chromax, resulting in shorter cycles, helps speed up production. The reduction in weight made possible by these exceptional alloys, coupled with their *high heat and corrosion-resistant qualities*, results in appreciably lower heat-hour costs.

And heat-hour costs are the primary consideration. Heat-treating equipment that proves *most economical in the long run*—by delivering more hours of efficient, trouble-free performance—is the *most economical to purchase initially*. For this reason, it will profit you to consult with us. We not only can put the highest grade nickel-chromium alloys at your disposal, but—with over 40 years of practical foundry experience to our credit—can give you sound and valuable assistance.



Cast Nichrome
Pit Type Retort
8' 6" x 2' diameter.
Wt.: 2331 lbs.



New Model Cast Nichrome Rotary Carburizing Retort. Wt.: 600 lbs.



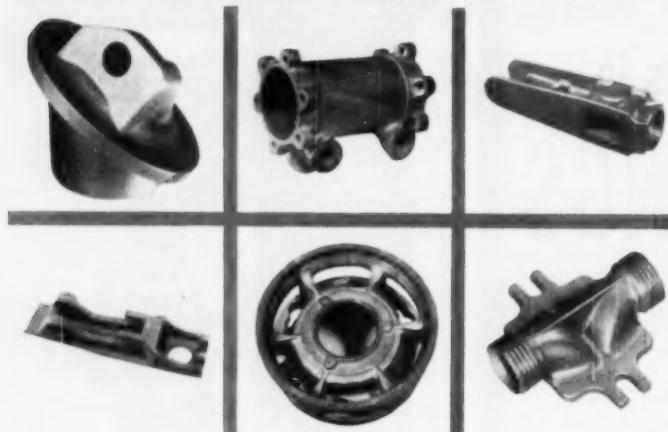
Fabricated Cast Nichrome
Shaker Hearth Muffle. Wt.: 595 lbs.

Photos courtesy of
American Gas Furnace Co.

Nichrome and Chromax are manufactured only by
Driver-Harris Company
HARRISON, NEW JERSEY
BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. Reg. U. S. Pat. Off.

THE ULTIMATE IN PRECISION CASTINGS



These intricate precision castings made from frozen mercury patterns assure you of soundness—accuracy—close tolerances—60-80 micro finish and minimum finishing in size ranges not available by conventional casting methods. All ferrous and non-ferrous metals. Inquiries invited. Brochure on request.

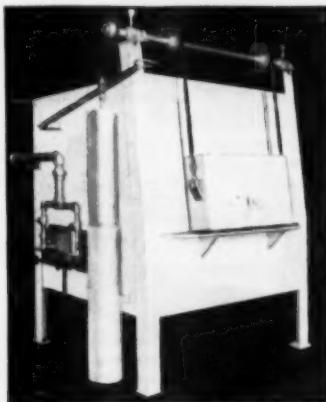
MERCAST
PROCESS

ALLOY PRECISION CASTINGS COMPANY

EAST 45th ST. AND HAMILTON AVE.

CLEVELAND 14, OHIO

for Annealing—Hardening—Drawing
Carburizing—Normalizing—



Rockwell builds many types of batch or conveyor furnaces and ovens; strip and wire winding and cleaning machines; handling equipment; non-ferrous rod mills; special fabrications.

ROCKWELL STANDARD OVEN FURNACES

- Oil, gas or electric.
- Wide heating range.
- Simple—rugged—economical.
- Rapid, uniform heating.
- Accurate duplication of heating results.
- Controlled temperature and atmosphere.
- 18 standard sizes.
- May be provided with muffles, cooling chambers, doors at both ends, etc.

Write for Bulletin 413.

W. S. ROCKWELL COMPANY
204 ELIOT STREET • FAIRFIELD, CONN.

Stabilized 18-8

(Discussions start on p. 691)
constant but varies probably according to the oxidation of the melt, the bulk and consistency of the slag, and so on. With a normal addition of 1% titanium the residual titanium in the finished steel will generally lie between 0.65 and 0.85%, although both higher and lower figures do occur. It is always found that no titanium is recovered from titanium-bearing scrap included in the charge. These remarks refer to electric-arc furnace melts.

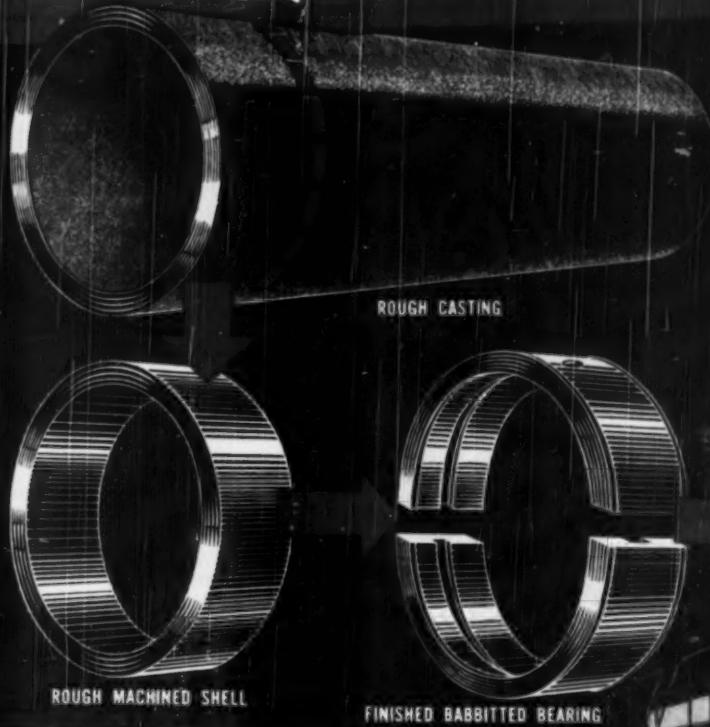
The carbon contents of these steels are usually appreciably lower than the specified maximums, but, irrespective of the final analysis, each cast is tested for resistance to intergranular corrosion before it is allocated and put into production. This "cast test" does not replace the tests carried out on the finished products, which are tested strictly in accordance with the relevant specification, but such "cast tests" are regarded as the criterion of the suitability of the cast. The analysis, as such, is not an infallible indication. It has not been found that titanium is progressively lost during the teeming of ingots from 20-ton arc furnace casts.

By comparison, the columbium yield is not so variable and about 80% of the amount added is regularly retained and something like 75% is recovered from the scrap.

Perhaps the most striking difference between titanium and columbium additions is in their respective effects on the fluidity of the molten steel. The addition of ferrotitanium seems to cause a "thickening" so that the metal does not run so freely and it has been found that whereas a 1½ or 2-in. dia. nozzle is necessary for adequate teeming of the titanium-bearing steel, the columbium-bearing type can be satisfactorily teemed through a 1½-in. dia. nozzle. As a result of the "thickening" effect, the surfaces of the titanium-treated steel ingots are not so good as the columbium-treated type, although it will be obvious, in view of the large tonnage of the titanium-treated steels that has been made, that the yields are commercially economical. That apart, the materials are not noticeably different in normal hot working.

In respect to cold rolling, no significant difference seems to exist
(Continued on p. 764)

ROUGH *Right* AND READY



IN ROUGH FORM . . . "as cast" . . . ready for other specialists to fabricate or to finish—that's how we supply castings to a growing list of America's quality-minded industries.

These bearing backs, for example: Worthington Pump and Machinery Corporation uses them in their entire line of Heavy Duty Supercharged Oil, Gas and Dual Fuel Diesel Engines. We furnish the rough castings in random lengths of from 4 to 10 feet. Worthington finishes them—machines, tins and babbitts to their own specifications.

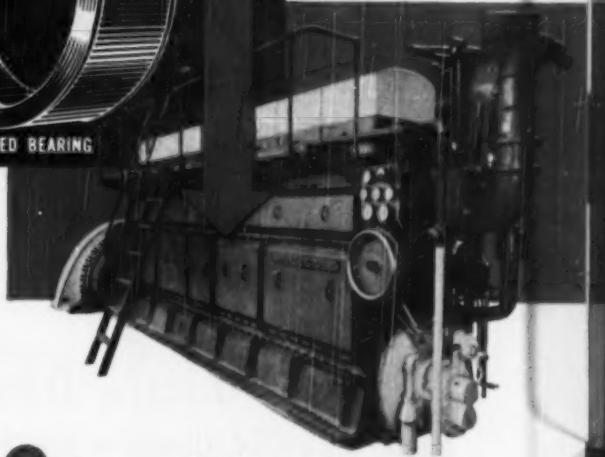
The result is a bearing shell with the following distinct advantages:

- 1 Metal mold centrifugally cast gray iron has high tensile strength and uniform grain structure highly satisfactory for tinning and babbiting the bearing face.
- 2 This soundness provides for uniformity of bond. Minimum babbitt thickness assures efficient operation and maximum bearing life.
- 3 Rough castings are annealed dead soft allowing maximum machining speeds and feeds for iron—keeping machining cost to a minimum.
- 4 The annealed gray iron centrifugally cast bearing back stock properly machined will not spring out of shape when split to make bearing halves.
- 5 In the event of babbitt failure, the cast iron back won't injure the journals of the crankshaft.

U. S. PIPE AND FOUNDRY COMPANY SPECIAL PRODUCTS DIVISION

BURLINGTON, NEW JERSEY
AMERICA'S LARGEST PRODUCERS OF CENTRIFUGALLY
CAST FERROUS METAL PRODUCTS IN TUBULAR FORM

WORINGTON'S popular Heavy Duty Supercharged 16 x 20 Diesel Engine is equipped with centrifugally cast bearing backs supplied "as cast" for finishing by Worthington to its own specifications.



- 6 Losses incurred in finishing are held to a minimum.

Like to know whether metal mold centrifugally cast iron, steel and stainless steel is the answer to your particular problem? Write and outline your tubular product requirements today. Our engineers will gladly forward the facts.



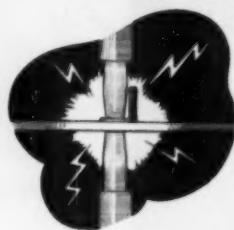
Centrifugally cast—will 100% Types, plus special heat and corrosion
resistant analyses.
Also Steel—will provide:
Tinless Steel—will provide
Gray and Alloy Iron—will provide and special analyses,
including tinless and stainless.
Dual Material—Gray or alloy, for use in steel-gray iron
with other iron or steel—will provide.
Tinless Steel—will provide.
Gray and Alloy Iron—will provide and special analyses,
including tinless and stainless.
Centrifugally cast combinations.

SIZE RANGE

Overall diameter—2" through 30".
Wall thickness—up to 2".
Lengths—up to 10'.

OHIO WELD SCREWS

For Economical Spot Welding



Ohio
SS Spotweld Screws

Thread Sizes,
No. 6-32 to $\frac{1}{2}$ -20

Materials:—Low Carbon Steel,
Brass or Stainless Steel.



For dependable Projection Welding
Ohio GW and HW Weld Screws

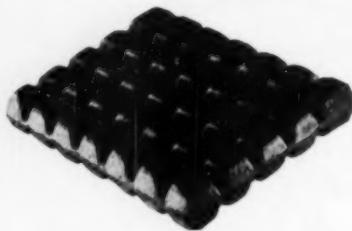


Thread Sizes,
No. 6-32 to $\frac{1}{2}$ -20



Materials:—
Low Carbon Steel,
Brass or Stainless Steel.

For list of stock sizes and samples, send to
THE OHIO NUT & BOLT COMPANY
25 FIRST AVE. BEREAL, OHIO



A Little Does a Lot

GCC CERIUM METAL (Mischiemetal)
added in small quantities to many Ferrous and Non-Ferrous Metals improves the metallurgical and mechanical properties of the end products.

Discover how a little does a lot by writing for our informative bulletins.



GENERAL CERIUM CO.
EDGEWATER, NEW JERSEY

Stabilized 18-8

(Discussions start on p. 691) Between the work hardening rates of the two types of steel if the chromium-nickel ratio is the same. However, there seems to be a clear difference in the bend tests—both close and reverse—especially after the heavier reductions.* This indication of reduced ductility in the columbium-bearing steel is not similarly reflected in the elongation values, whereas Mr. Tyrrell's tests show lower elongation values for the columbium-bearing steel at temperatures up to 1000° F. These observations, however, taken in conjunction with the two stampings shown in Fig. 1 of the paper, do indicate some comparative lack of ductility in the columbium steel.

There appears to be no particular preference among welders for either type of stabilization. In any event, several instances have been observed where the two types have been satisfactorily welded to one another in the construction of certain fabricated parts. There appears to be in this country a strong bias among welding rod makers in favor of columbium-stabilized rods.

Mr. Tyrrell's observation on the relative resistance to oxidation of the two types at temperatures of about 1300° F. is interesting. A ferrotitanium alloy commonly in use in this country and containing approximately 23% titanium will generally contain 7 to 10% aluminum. If it can be assumed that the alloy used in America is of a similar type, may it not be that the improved oxidation resistance of the titanium-bearing steel is influenced by its aluminum content? Mr. Tyrrell's observation does not seem to have been generally noted in this country.

Because of the "scatter" frequently found in creep test results, extensive data are necessary for any reasonable differentiation to be made, but, from the somewhat limited data at his disposal, the writer would have (Continued on p. 766)

*EDITOR'S NOTE: The writer of this letter, Mr. H. Allsop, has submitted extensive tabular data showing results of tensile, close bend and reverse bend tests on three heats of each type of stabilized steel. Each steel was tested after nine different reductions by cold rolling. A copy of Mr. Allsop's data will be sent free upon request to the Editor of *Metal Progress*.

FREE HANDBOOK ON ORGANIC SOLVENTS

Missouri Solvents & Chemicals
Company
629 Indiana Avenue
St. Louis 1, Missouri

Tells about

- FLASH POINT • DRY TIME
- TOXICITY • SOLVENT POWER

No cost! No obligation! We'd like to present you with this handy 64-page handbook solely to acquaint you with your nearby member of the SOLVENTS & CHEMICALS GROUP.

You'll find page after page in this book packed with information...written specifically for non-technical personnel. You'll find hundreds of definitions, comparison tables, testing methods and product descriptions on a wide variety of organic solvents in common use. And this handbook is in a convenient "pocket size"...easy to carry, easy to refer to!

This book is yours absolutely FREE. And if you'd like further information on a particular problem, your nearby GROUP MEMBER will be happy to study your problem and make expert recommendations...all without obligation. Take advantage of this offer today. Call or write your nearest SOLVENTS & CHEMICALS GROUP MEMBER. Order as many "Organic Solvent" handbooks as you need.



CALL OR WRITE TO THE MEMBER LISTED BELOW
THE SOLVENTS & CHEMICALS GROUP
ASSOCIATED FOR BETTER SERVICE TO INDUSTRY

OFFICES AND PLANTS IN

BUFFALO—BUFFALO SOLVENTS, Box 73, Station B.....	EDford 1572
CHICAGO—CENTRAL SOLVENTS, 2545 Congress St.....	SEaley 3-0505
CINCINNATI—AMSCO SOLVENTS, 4619 Reading Road.....	MElrose 1910
CLEVELAND—OHIO SOLVENTS, 3470 W. 140th St.....	Clearwater 1-3770
DETROIT—WESTERN SOLVENTS, 6472 Selkirk Ave.....	WAlnut 1-6350
FORT WAYNE—HOOSIER SOLVENTS, Maumee & Buster Rd.....	ANTHONY 0213
GRAND RAPIDS—WOLVERINE SOLVENTS 1500 Century Ave. S.W.....	Gr. Rap. 5-9111
HOUSTON—TEXAS SOLVENTS, 8301 Market St.....	Woodcrest 9681
INDIANAPOLIS—HOOSIER SOLVENTS, 1630 Luett St.....	ATlantic 1361
MILWAUKEE—WISCONSIN SOLVENTS, 1719 S. 83rd St.....	Greenfield 6-2630
NEW ORLEANS—SOUTHERN SOLVENTS, 1332 Jefferson Hwy.....	Temple 4666
ST. LOUIS—MISSOURI SOLVENTS, 419 DeSoto St.....	GArfield 3495
TOLEDO—WESTERN SOLVENTS, Central & Reynolds Rd.....	Jordan 0761

Alloy Castings for the HEAT-TREATING INDUSTRY

Economical Fahrite alloy

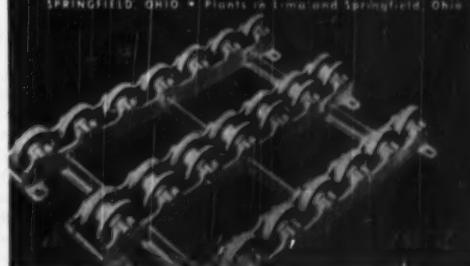
castings can be made to
withstand severe thermal
shock. The grade of Fahrite
depends on the application.
Let our engineers and metallurgists
analyze the requirements
of your heat and corrosion
problems.

FAHRITE
HEAT AND CORROSION
Alloys



THE OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO • Plants in Lima and Springfield, Ohio



Tempilstiks®

the amazing
Crayons
that tell
temperatures



A simple method of controlling temperatures in:

- WELDING
- FLAME-CUTTING
- TEMPERING
- FORGING
- CASTING
- MOLDING
- DRAWING
- STRAIGHTENING
- HEAT-TREATING IN GENERAL

Also available in pellets and liquid form

It's this simple: Select the Tempilstik® for the working temperature you want. Mark your workpiece with it. When the Tempilstik® mark melts, the specified temperature has been reached.

\$2

gives up to 2000 readings

Available in these temperatures (°F)

113	263	400	930	1500
125	275	450	1000	1550
138	288	500	1030	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000

FREE -Tempilstik® "Basic Guide to Ferrous Metallurgy" - 16 1/4" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

GORDON SERVICE

CLAUD S. GORDON CO.

Specialists for 36 Years in the Heat Treating and Temperature Control Field

Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

Stabilized 18-8

(Discussions start on p. 691) thought that the columbium type was usually superior in this respect.

There is no doubt that, with the exception of the special high-temperature alloys for specific purposes, and welding rods and some castings, practically all the needs of those industries requiring stabilized stainless steel can be adequately met by the titanium-bearing steels. That Britain has fulfilled her needs in these directions for many years without serious recourse to columbium-containing steels is proof enough of the statement.

H. ALLSOP
Director of Research
Brown, Bayley's Steel Works, Ltd.

Stabilized Stainless Plate

COATESVILLE, PA.

The experiences of Lukens Steel Co. in the production of plates and in the hot and cold forming of heads from plates of Types 347 and 321 stainless steel are very much in line with those outlined in Mr. Tyrrell's paper.

Type 321 is easier to roll into plate since it has greater plastic flow at rolling temperatures than 347. Less difficulty also is encountered in forming heads of 321 than of 347, due no doubt to its greater ductility at both high and atmospheric temperatures.

Type 321 exhibits good welding characteristics as well as good resistance to high temperatures, and is at least comparable to Type 347 in these respects.

It is the writer's opinion that, in view of the shortage of columbium, promotion of Type 321 should be encouraged where weldability, rather mild corrosion resistance, formability, and high-temperature oxidation are important factors.

J. G. ALTHOUSE
Metallurgical Engineer
Lukens Steel Co.

More on British Aircraft

EDGWARE, ENGLAND

I am in substantial agreement with Mr. Tyrrell's lucid and well-put argument for the use of titanium-stabilized and heat resisting alloys of the austenitic chromium-nickel family. For American readers any comment probably should be prefaced by a note as to the British

(Continued on p. 768)

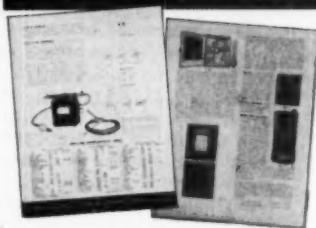
Want to know more about

GAS ANALYSIS?

Read this
New 8-page
ENGELHARD
BULLETIN



Look at these
Data-Packed Pages



YOU WILL FIND a wealth of material on a wide range of gas analysis problems and their solutions in the new Engelhard 8-page illustrated bulletin. It explains how Engelhard equipment provides complete, sensitive, accurate analyses by the proven thermal conductivity method. The bulletin also contains a valuable thermal conductivity table that you will want to keep for handy reference. Write for your free copy today. Ask for Bulletin 800A.

Please send me FREE copy of Bulletin 800-A on Gas Analysis.

Name _____

Company _____

Address _____

City _____ State _____ X1234

CHARLES ENGELHARD, INC.
850 PASSAIC AVENUE, EAST NEWARK, N. J.

Now! Another B&A First!

B&A HYDROFLUORIC ACID

Packaged in New Plastic "Jug"



For Industrial Use

B&A pioneered packaging chemicals in plastics when it introduced its famous laboratory Safepak[†] for B&A Reagent Hydrofluoric Acid.

Now, B&A offers industry Hydrofluoric Acid and other liquid chemicals in an exclusive new plastic container designed to hold ten pounds of acid. This special container, weighing only 2 pounds, overcomes the difficulties previously experienced with the old-fashioned heavy lead jugs. Review the many advantages outlined! Consider what they can mean to you. Then order your HF requirements from B&A today.

†General Chemical Trade Mark

Note these 8 big special features!

- 1 **Economical**—Lower tare weight for each 10 pounds of acid purchased.
- 2 **Stronger . . . Safer**—Bottle molded of shatter-proof plastic. Won't develop dangerous leaks common to lead containers.
- 3 **Lighter . . . No excess weight**—Two pound "jug" holds 10 pounds of acid. Compare with 17 pound lead container holding same amount.
- 4 **Easier to handle**—Convenient size and light weight insure ease of lifting and pouring.
- 5 **Easier to open**—Screw-type plastic cap makes re-closure easy; safeguards against spillage . . . leakage; protects purity. Compare with hard-to-remove rubber stopper on lead container.
- 6 **Easier to pour**—Special bottle design and pouring lip insure clean, accurate dispensing.
- 7 **Acid resistant**—Entire unit made of polyethylene: highly resistant to aqueous HF, other acids.
- 8 **Acid level always visible**—Translucent plastic eliminates guesswork or measuring sticks.

PACKING: Four bottles cell-packed in standard returnable wooden shipping case . . . easy to handle . . . easy to store . . . easy to return. Single bottles available in sturdy wire-bound box.



BAKER & ADAMSON Fine Chemicals

GENERAL CHEMICAL DIVISION

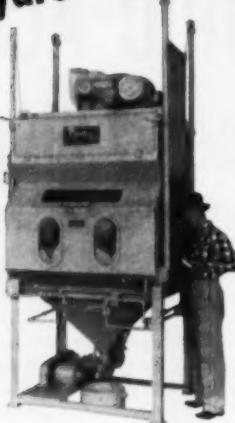
ALLIED CHEMICAL & DYE CORPORATION

— 40 RECTOR STREET, NEW YORK 6, N. Y. —
Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte •
Chicago • Cleveland • Denver • Detroit • Houston • Jacksonville • Los Angeles • Minneapolis
New York • Philadelphia • Pittsburgh • Providence • St. Louis • San Francisco • Seattle • Yakima (Wash.)
In Wisconsin: General Chemical Company, Inc., Milwaukee, Wis.

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver
SETTING THE PACE IN CHEMICAL PURITY SINCE 1882

*Complete stocks are carried here.

PANGBORN Hydro-Finish



gives you...

- Better Paint Jobs
- Better Electroplating
- Better Finishing
- Better Products

Slash finishing costs to rock-bottom in your plant! Amazing Pangborn Hydro-Finish cleans far faster than hand methods, yet holds tolerances to .0001". Hydro-Finish cannot harm your product's sharp edges or corners, forms a perfect "tooth" for non-peel electroplating, finishing or painting.

Hydro-Finish makes threaded pieces turn easily... forms millions of little "oil pockets" in lubricated pieces to prolong product life. Fatigue failure is reduced because Hydro-Finish removes or blends grinding lines, etc!

Hydro-Finish is also valuable in your tool room—cleans production tools and dies in a fraction of the time needed for expensive hand cleaning.

WRITE TODAY for Bulletin 1400-A. Contains full facts on Pangborn Hydro-Finish and Pangbornite Abrasive. For your free copy, address: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Maryland.

Pangborn

BLAST CLEANS CHEAPER
with the right equipment
for every job

British Aircraft

(Discussions start on p. 691)
equivalent of the American Types 321 and 347, and their changes in composition during the past dozen years. This is summarized in the accompanying table.

It will be noted that in the first two versions no mention is made of a stabilizing element, although such was usually necessary—particularly with the higher carbon casts. Freedom from intergranular embrittlement was safeguarded by a pickle-bend test.

Incidentally, even with the latest compositions the pickle-bend test is still a mandatory requirement. It will be appreciated, however, that a test of this nature can only control freedom from embrittlement at the temperature and conditions of test and need not necessarily indicate proof of satisfactory behavior at other temperatures. A test to cover all conditions is deemed impracticable and for this reason service experience is of greater importance.

In British specifications the analysis range is generally wider than in the American counterpart mainly because greater control is exercised in other directions, either by heat treatment and/or specified mechanical properties. With the type of steels in question, however, the composition range has gradually been tightened and is now comparatively closely controlled—although carbon content, a most important variable, is still wider than in Types 321 and 347. Generally, while no manufacturer produces a steel approaching the maximum permissible, the carbon content of the British steels is somewhat higher than the American, being of the order of 0.07 to 0.12%. This higher carbon

range makes stabilization against "weld decay" or intergranular embrittlement more important, and demands the use of carbide formers such as titanium or columbium. Hence the change to the postwar composition shown in the table.

Preference for Titanium in Welded Structures—Before the 1939 World War, titanium was almost universally used for stabilizing stainless steels. Although the use of columbium is increasing, owing chiefly to American influence as a result of the consumption of large quantities of American sheet during the war, titanium is still the preferred and more generally used stabilizer. Briefly, the main reasons for this are: Firstly, because the British are conservative in outlook and are slow to change already well-established practice; secondly, columbium is more expensive, in short supply, and is required for more important applications; thirdly, less titanium is required; and fourthly, the fabricator, and in particular the welder, prefers titanium.

This last may be due, to some extent, to inexperience in welding with columbium-bearing material, although columbium-bearing welding rod and fluxed wire have been in use for many years. The fact remains, however, particularly with thin-gage aircraft sheet, that more care has to be exercised to produce a clean, uniform weld, and greater difficulty is experienced in repairing welds in columbium-bearing material. The difficulty appears to be emphasized when welding columbium-stabilized material of widely dissimilar thicknesses.

From these remarks it must not be inferred that columbium-stabilized material cannot be used for welding purposes; much of it is already in general use. On the other hand, wherever a difficult weld cannot be avoided by design changes, there does seem to be a preference for titanium. (Continued on p. 774)

Compositions of British Stainless Steels for High-Temperature Weldments

ELEMENT	BRITISH EQUIVALENTS TO TYPES 321 AND 347			DTD 493	
	PRE-1939 WAR	WARTIME CHANGES			
		FIRST	SECOND		
Cr	>12.0	16.0/20.0	16.0/20.0	16.0/20.0	
Ni	6.0/20.0	7.0/12.0	7.0/12.0	8.0/12.0	
C	<0.20	<0.20	<0.20	<0.16	
Si	>0.20	>0.20	>0.20	>0.20	
Mn	<1.00	<1.00	<1.00	<1.00	
S	<0.05	<0.05	<0.05	<0.045	
P	<0.05	<0.05	<0.05	<0.045	
Ti	N.S.	N.S.	>0.50*	>5 x % C†	
Cb	N.S.	N.S.	N.S.	>10 x % C†	

*Not less than 5 x % C. †Alternative.

For New

CONVENIENCE in Laboratory Apparatus more ease, range, speed—

Specify* Precision
to be Sure

PRECISION Electrolytic Polisher offers new convenience in making "quickie" tests by micro-appraisal of many metals and alloys. "Cleans" entire surface in less than 2 minutes, without etch-patterns or special electrical equipment. Greater volume, faster; lower cost. Bulletin 5-936



PRECISION Semi-Auto. Specimen Mounter. Trim, self-contained unit with air-cylinder, automatically maintains pressure on specimen mount (no hydraulic jack), relieves operator. Dual thermostatic heat control, pre-set air control, bell curing-timer. Saves space and trouble, does best mounting. Bulletin 5-713

Other pre-tested products in the broad

Precision line—"utilities" to highly specialized instruments—can make your work easier, surer, more economical. Think which of your equipment needs replacement, where your facilities should be extended . . .

Order from your Dealer NOW!

... or write us for details on above or your individual problem . . . today.

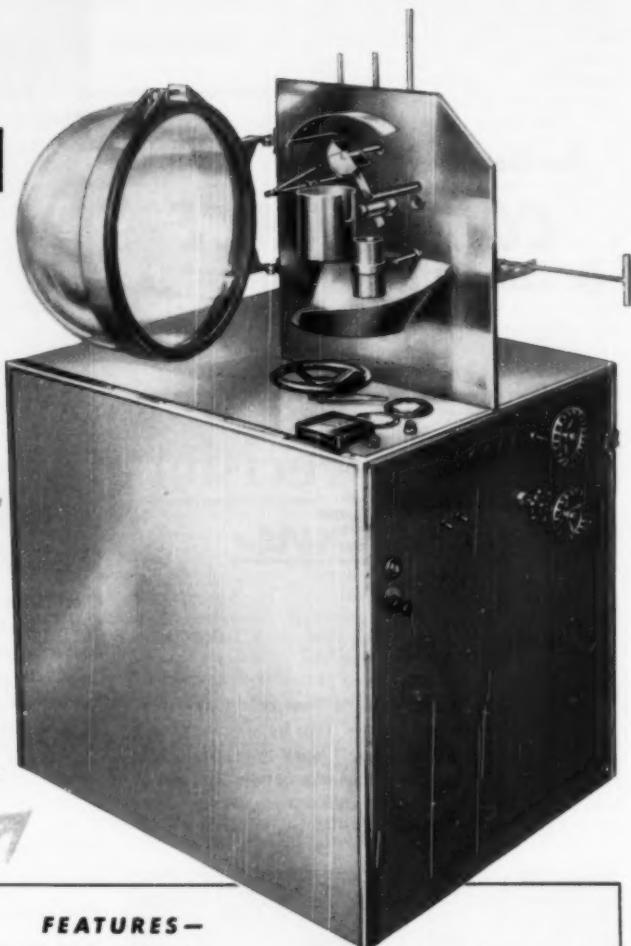
Precision Scientific Company

3737 W. CORTLAND STREET—CHICAGO 47

* FINEST Research and Production Control Apparatus
NEW YORK • PHILADELPHIA • ST. LOUIS • HOUSTON • SAN FRANCISCO

NOW You can afford a High Vacuum Furnace

ONE
This **Versatile Unit lets**
you melt, pour,
heat treat, degas



At last there is now available a single furnace that does away with the need to purchase equipment for each phase of your high-vacuum, high-temperature work. Because of its modest price, it will fall within the budget of most laboratories.

With this new furnace you can melt and solidify — melt and pour — add to the melt — stir — look into the hot zone — measure hot zone temperatures — introduce controlled atmospheres — degas — heat treat. It's a complete, versatile unit, capable of handling the widest variety of metallurgical research work. Write today.

FEATURES —

- Ultimate vacuum of less than 5×10^{-5} mm. Hg.
- Working temperatures up to 2000° C.
- Temperature controllable within $\pm 5^\circ$ C.
- Hot zone reaches temperature within one minute.
- No refractories used in hot zone.
- 4" purifying type diffusion pump insures high capacity for out-gassing.
- Utilizes single turn low voltage resistance element of either tungsten or molybdenum 8" x 2½" dia.
- Constant temperature zone 6" x 2½" dia.
- Power supplied directly from mains to specially-designed variable auto transformer which is an integral part of unit.
- Either manual or automatic temperature control or both.
- Thermocouple vacuum gage is standard equipment. Other gages are available.
- Furnished complete with vacuum system, controls and gages including ammeter, volt-meter and temperature indicator.

INDUSTRIAL RESEARCH • PROCESS DEVELOPMENT
HIGH VACUUM ENGINEERING AND EQUIPMENT



METALLURGY • DEHYDRATION • DISTILLATION
COATING • APPLIED PHYSICS

National Research Corporation

Seventy Memorial Drive, Cambridge, Massachusetts

In the United Kingdom: BRITISH-AMERICAN RESEARCH, LTD., London S.W. 7 — Wishaw, Lancashire

PRODUCTION UP 83%

ON THIS INTRICATE TEXTILE
MACHINE PART

Textile Machine Part
LA-LED replacing C-1117

Size: $1\frac{5}{8}$ " round
Produced on: Greenlee Automatic

RESULTS:

Form Tool Speed	— + 88%
Form Tool Feed	— + 4%
Drill Speed	— + 81%
Drill Feed	— + 7%
Time/part	Decreased 46%
Production	Increased 83%
Steel cost	Increased 18%



NEW

LA-LED

THE FASTEST MACHINING
BAR STEEL ON THE MARKET

Also Provides Close Tolerances, Fine Finish, Good Carburization

A glance at the above figures—taken from an actual production run—will reveal the amazing production increases which are possible when ordinary screw steel is replaced with LA-LED—the fastest machining steel you can buy.

LA-LED is an entirely NEW steel, unlike anything produced before. It has a unique composition which allows startling machining speeds. However, it offers much more. Being

an open-hearth steel, it has a much sounder cross section than Bessemer. Its good ductility and surface quality permit bending, crimping, and riveting operations impracticable with Bessemer steels. And, LA-LED machines to a fine satiny finish and provides closer tolerances. LA-LED is available cold-finished—in rounds $5/16$ " through 3"; in hexagons $5/16$ " through $1\frac{1}{2}$ ".

WRITE FOR DESCRIPTIVE PAMPHLET

LaSalle Steel Co.

1494 150th Street, Hammond, Indiana

Please give me more information on how LA-LED can increase production and cut the cost of screw machine parts in my shop.

Name _____

Title _____

Company _____

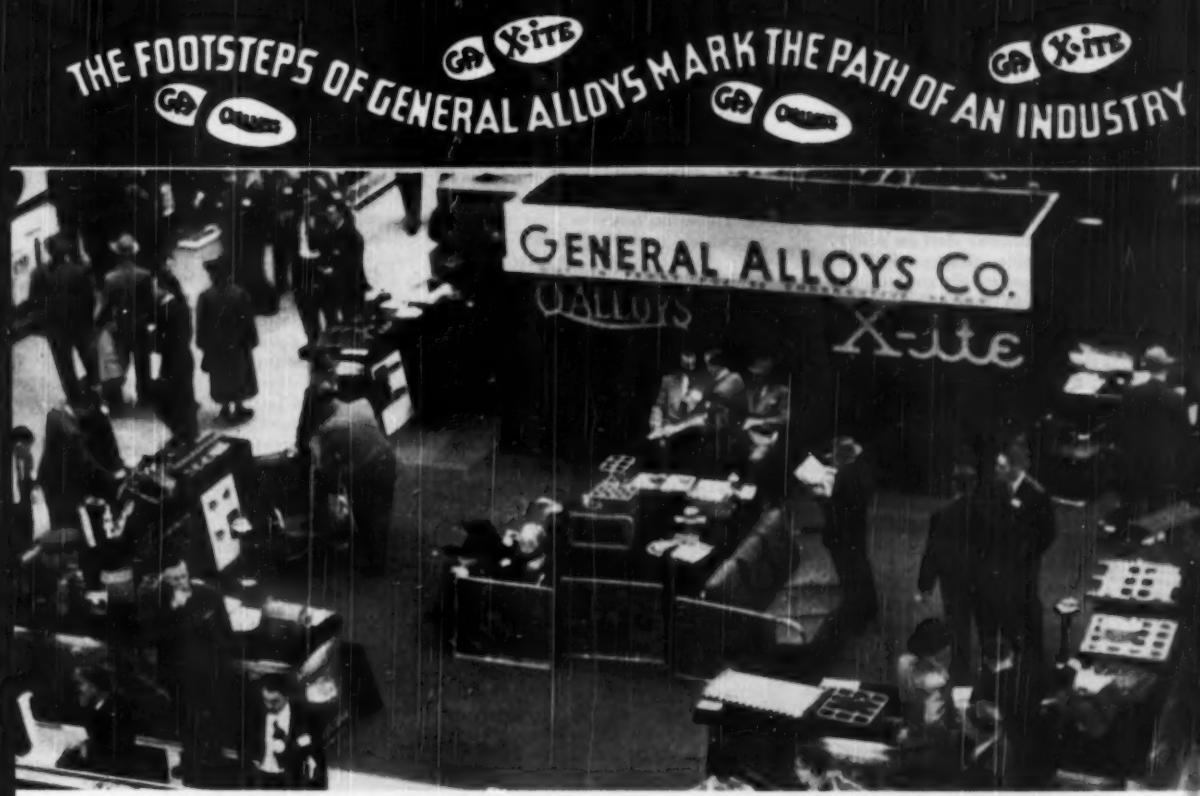
Address _____

City _____

State _____

LaSalle STEEL COMPANY

Manufacturers of the Most Complete Line of Carbon
and Alloy Cold-Finished and Ground
and Polished Bars in America



NICKEL "SHORTAGE"

General Alloys yields to no one in Pioneering High Nickel-Chrome Alloys.

We are morally responsible to serve our customers with the best products we can produce. Most alloy users recognize their moral responsibility to *reserve their scrap alloy castings for their casting suppliers*, not sell them to profiteers or those engaged in circumventing anticipated Government allocations. Beyond this, they recognize that the *continued function of their heat treats is utterly dependent on the continued supply of good alloy castings and adequate spare parts to protect against breakdown*.

Does the Government have a moral *responsibility* not to close down small industries — losing specialized labor and engineers — unless such procedure would serve the national interest?

Do you believe that the Government is so naive that it does not recognize that a 20% increase in nickel prices, and that hoarding ("stock-piling") of nickel, would not bring wild profiteering in nickel scrap and a hopeless mix-up in scrap and its normal flow? Yet, there has been nothing done to peg scrap prices, which, in some instances, have increased 400%.

Clearly, if we are in a "National Emergency" through inadequate nickel production and failure of the Government to stockpile nickel, it is as necessary to control scrap as to control new nickel. (In the last war, nickel scrap was pegged at 26½ cents against 32 cents for new nickel.)

General Alloys' policy has been, to date, to melt virgin nickel, using small quantities of our own scrap only in our lower grade alloys. Some other producers, however, regularly use large quantities of scrap and with even less nickel were hit even harder by a 50% curtailment of nickel (to cuspidor platers and basic industry alike) by Government action, and they are in a mad scramble for scrap, for *self-preservation*. We may soon join them.

Obviously, scrap dealers' huge profits must be reflected in alloy casting prices. Just as obviously, the substandard alloys, enforced by this *Government action and inaction*, will have unpredictable service and present a grave hazard to heat treats operating in defense and basic industries.

Some intelligent, conscientious Government officials are striving to correct this situation and some relief may appear in November. Meanwhile, hold your scrap alloy castings for a legitimate alloy producer, or take your chances on what you get from the alloy casting industry.

GENERAL ALLOYS AT NATIONAL METALS EXPOSITION

LARGEST AND ONLY CONTINUOUS
ALLOY CASTING EXHIBITOR FOR

32 Years!

Acknowledging the responsibility of leadership, General Alloys exhibited as usual for the 32nd consecutive year at the main entrance of the National Metals Exposition. More Engineered, High Temperature Tooling and diversified heat and corrosion resistant castings were shown in the G.A. booth than elsewhere in the entire Show.

We salute those competitors who had the courage to participate in the Show, despite the chaotic mess on nickel and nickel scrap which was thrust on this industry and its customers.

We sympathize with those who were forced to withdraw from the Show by the crippling of their operations and/or their inability to accept orders in a rising demand for their product in all the basic industries vital to Defense and in the projected rise of defense production.

If you visited the G.A. booth at the Chicago Show you understand the outstanding progress that research and development, superimposed on 32 years of experience, have brought about in our product. Much more will come.

Until this date, General Alloys' metallurgical quality has been scrupulously maintained on X-ite by largely discontinuing X-Alloys. If, as seems probable, production of substandard alloys is forced upon us and upon you by Government regulation, we will clearly identify such castings.

Technic

GENERAL ALLOYS COMPANY • BOSTON

QALLOYS

THE QUALITY NAMES IN ALLOY
FOR HEAT CORROSION ABRASION

X-ite

British Aircraft

(Discussions start on p. 691)

The main disadvantages in the use of titanium are oxidation losses at the weld, and also that part of the titanium may be present in the steel as nitride and so does not exert any stabilizing influence.

Until comparatively recently the majority of experience in fusion welding has been with gas welding and later with the metallic arc where oxidation losses are of some importance. By the increasing use of inert gas atmospheres, such as are produced by atomic hydrogen and the argon arc, this criticism is of less significance.

Effect of Lower Carbon Content

— There is a gradual leaning in this country toward a lower carbon stainless steel of the order of 0.03 to 0.05% C. This will eliminate, for many applications, the need for stabilization. This trend will help in many respects, in that steelmaking will be simplified, forging and rolling made easier, as well as fabrication simplified in the consumer's

plant. Moreover, a higher standard of finish, free from titanium segregation so often disclosed toward completion of manufacture, will also be possible.

There is, however, one distinct drawback from the aircraft designer's point of view. As part of the design procedure of structural components a design factor is employed based either on 0.1% proof stress (or on ultimate tensile stress, which ever is the lower). In the case of softened stainless steel the 0.1% proof stress is the operative value, and with existing specifications the minimum figure is 13 to 15 tons per sq.in. (29,200 to 33,600 psi.). With stainless steels containing 0.03% carbon this property would be reduced to the order of 10 tons per sq.in. (22,400 psi.) — a serious reduction where weight is of paramount importance.

Elevated Temperature Properties

— With the introduction of gas turbine engines a further influence comes into play in regard to properties at elevated temperature. Hitherto the emphasis has mainly been on the use of a stable and scale resisting steel, but with gas turbines a wider field of application becomes available and some improvement in

hot properties is of considerable interest.

For example, the use of either titanium or columbium can have a pronounced effect, given a suitable thermal treatment, and will provide adequate creep performance for many applications where previously a more expensive and complex steel has been necessary. In this direction it is suggested that more effort be put into research to determine a useful general-purpose and comparatively cheap alloy with heat and scale resistance for use in turbine parts where temperatures are relatively moderate. Much work is already being done, one instance being the use of molybdenum-bearing steels for this purpose, but the scope is wide.

A considerable quantity of the 18-8 type of heat resisting steel (DTD571) is used in sheet metal parts such as tail pipes and extensions, rear cones, deflector and baffle plates on the turbine and, wherever possible, for exhaust manifolds and collector rings on piston engines. This steel is quite adequate for temperatures up to 700° C. (1300° F.). For higher temperatures a steel somewhat similar to the American Type 310

(Continued on p. 776)

KORN'S
METAL MARKING CRAYONS

FOR MARKING
ALL TYPES
HOT—COLD—
WET OR DRY
METALS

Will Not Rub Off...
Waterproof... Will
Not Run.

Appears as Paint
When Used on
Hot Metal.

Samples and Price List
on Request.

Wm. KORN, Inc.
260 WEST ST. • DEPT. MP • N.Y. 13, N.Y.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

Required by the Act of Congress of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (39 U.S.C. 233) of **Metal Progress**, published monthly at Cleveland, Ohio, for October 1, 1950.

1. The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Managing Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Business Manager, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

2. That the owner is: The American Society for Metals, 7301 Euclid Ave., Cleveland, Ohio, which is an educational institution, the officers being: President, A. E. Focke; Vice-President, W. E. Jominy; Secretary, W. H. Eisenman; Treasurer, R. E. Wilson; Trustees: H. K. Work, F. J. Robbins, H. P. Crott, T. G. Digges and Elmer Gammeter, All officers as above, 7301 Euclid Ave., Cleveland, Ohio.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

W. H. Eisenman,
Business Manager.

(Seal)
Sworn to and subscribed before me this 1st day of October, 1950.
Genevieve G. Fitzgerald
Notary Public.

(My commission expires March 26, 1952.)



Baldwin—Tate—Emery Universal Testing Machines

Tate-Emery weighing system, entirely separate from loading system . . . Servo drive provides outside source of power, overcomes drag, provides excess energy to operate maximum hand, recorder, load maintainer and other auto-controls . . . multi-range dial . . . selection variable during test . . . widest span of ranges—200 to one or greater . . . accuracy of $\frac{1}{2}\%$ guaranteed down to 20% of each range . . . ASTM accuracy guaranteed to 10% of each range . . . demonstrated sensitivity shows 1 pound in a million . . . zero essentially positive . . . negligible hysteresis, creep or temperature errors . . . complete calibration and maintenance service . . . installation by a qualified Baldwin field engineer.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U.S.A. Offices: Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.



TESTING

HEADQUARTERS

Conservation of Ch

(Discussions start on p. 691)

is used, namely, the DTD 493 shown in the last column of the table. Its higher chromium content improves the scale resistance; temperatures up to 850°C. (1550°F.) are quite permissible. It should be mentioned that this specification is also being brought into line with the 18-8 type, in that the stabilizing elements titanium or columbium are to be specified in relation to carbon content.

High-Strength Alloys at Elevated Temperatures—With regard to titanium and columbium in high-strength, high-temperature applications for gas turbine rotating blades, and in like situations, British practice differs fundamentally from American. In this country universal use is made of the wrought "Nimonic" alloys (nickel-base with 20% chromium, containing titanium and aluminum as precipitation elements) and there does not appear to be any likelihood of a change for established engines, at least in the immediate future. Other alloys are

being developed and tested; however the only alternatives contain high proportions of cobalt and for this reason are not encouraged.

K. W. CLARKE
Central Laboratory
De Havilland Aircraft Co., Ltd.

Steps Toward Conservation

SHEFFIELD, ENGLAND

The challenge implicit in Mr. Tyrell's article is a particularly useful one to face at the present time when it is appreciated that columbium would be in very short supply if a full-scale war emergency occurred and when in any case its better utilization is prudent.

It is significant that during World War II the Germans reserved their slender stock of columbium for adding to welding wire (and maybe plate material) for welding only the most critical chemical vessels, which presumably operated at the highest temperatures. British experience bears out the fact that columbium-bearing stainless steels are preferable under such conditions, but there would be no hesitation in adopting titanium-stabilized steels in a national emergency when economics and the life of a plant could be regarded as secondary.

In what way is columbium-stabilized steel or welding-rod material superior to titanium-stabilized? The answer is twofold. Firstly, titanium oxidizes more rapidly than columbium when the steel is molten during arc welding and the titanium carbide will dissociate to form titanium oxide and quite probably titanium nitride. Very often there is present some aluminum derived from the ferro-alloy, which oxidizes to alumina. Some additional alumina may also be present and thus inclusions in titanium-bearing steels are often rich in both types of oxide, besides some titanium nitride. The nitride can form a continuous series of solid solutions with the carbide and this in turn can give rise to the titanium cyanonitride, salmon-colored cubic crystals often seen under the microscope. If the steel containing these unwanted constituents is highly stressed and subject to fatigue in alternating tension or bending, it has been reasonably contended that failure is promoted by these metallurgical stress-raisers. For this reason some British valve steels for internal combustion engines have to be supplied free from all titanium additions. Columbium is permitted, and indeed

(Continued on p. 778)

Columbia TOOL STEEL

PRODUCTION

For today's heavy die production needs, nothing excels SUPERDIE, the special high carbon-high chromium die steel.



COLUMBIA TOOL STEEL COMPANY

ARTHUR T. CLARKE, PRESIDENT
MAIN OFFICE AND WORKS
500 EAST 14TH STREET • CHICAGO HEIGHTS, ILL.

A COMPREHENSIVE METALLURGICAL INDEX

WHAT IT IS:

The ASM-ALA Metallurgical Literature Classification is a subdivided outline of the entire science of metallurgy that provides a guide to the filing and indexing of metallurgical literature and data collections. It can be used with standard card indexing and literature filing systems or with a specially designed punched-card system. The complete classification outline and instructions for its use are contained in a handy 8½ x 11 paper-bound booklet, selling for a dollar.

WHO MADE IT:

The classification was prepared by a joint committee of the American Society for Metals and the Special Libraries Association. Its authority, accuracy and completeness have been checked by experts in all branches of metallurgy.

WHAT DO I NEED?

First, the booklet containing the classification proper—essential for all purposes. Second, a set of looseleaf worksheets which provide capacity for the individual user to expand minor fields, to add new subjects, and to develop desired sidelines—essential only for the user who wishes more detail than provided in the existing outline. Third, Punched cards and punched-card equipment—a new and efficient bibliography filing method.

WHERE DO I GET IT?

The classification book and the Worksheets are available from the American Society for Metals, 7301 Euclid Ave., Cleveland, Ohio. The punched cards and punched-card equipment may be purchased from Lee F. Kollie, Inc., 35 East Wacker Dr., Chicago 1, Ill.

For further details, write:

AMERICAN SOCIETY FOR METALS
7301 Euclid Avenue
Cleveland 3, Ohio



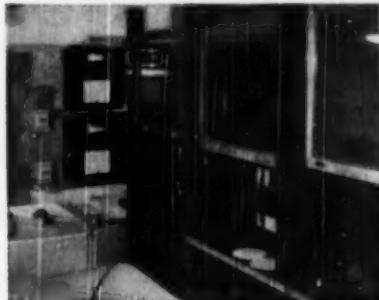
AT DONOVAN COMPANY — Heat Treating —
In this completely Wheelco equipped shop the CAPACILOG is used on a gas-fired 48" hardening furnace. It operates with a solenoid valve.

AT METLOX MFG. CO. — Pottery —
To keep a complete permanent record of the critical temperatures needed for firing fine figurines and dinnerware, a CAPACILOG is mounted on the tunnel kilns of this quality goods manufacturer.

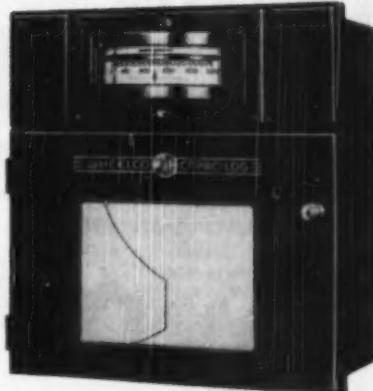


Instrumentality in action...for economy

Leading manufacturers in the various process industries use the WHEELCO CAPACILOG to assure more profitable use of process equipment. From original cost through more efficient production, the CAPACILOG gives more economical *permanently recorded control* of electrically measurable variables.



AT U.S. DEPT. OF AGRICULTURE — Laboratory —
In the Grain Branch, Department of Production and Marketing, where grain samples are tested, the CAPACILOG is used to control and record the temperatures of muffle furnaces.



...wheelco capacilog

A direct reading, deflection type, strip chart recorder which gives you continuous, fast, simple and accurate reproduction of industrial processes. You get measurement, indication and control with a permanent record of temperature, speed, static strain loads, AC-DC voltage, amperage and other electrically measurable factors with the Wheelco Capacilog.

specify Wheelco for the economy of instrumentality

Write for Bulletin C2 • WHEELCO INSTRUMENTS COMPANY • 835 W. Harrison Street, Chicago 7, Illinois

wheelco  **electronic controls**

Conservation of Columbium

(Discussions start on p. 691) is added in small quantities, with much benefit, to eliminate progressive embrittlement.

Turning now to arc welding, when using columbium we find that the columbium carbide is remarkably stable even when the metal is molten, and that the weld metal contains about 75 to 85% of the expected columbium content. Recent work has shown, however, that the excess columbium (over and above that required to combine with the carbon present) combines with the iron and silicon present to form new brittle intermetallic phases, the incidence of which seems to be one of the main causes of weld-metal cracking in austenitic steels of the 347 type. A forthcoming publication by E. Bishop and W. H. Bailey will deal with this aspect of the matter, but in passing it is highly probable that some of these phases were present in the 347 steel used by Mr.

Tyrrell, and may have influenced his formability tests, because on the average 85% more columbium was used than was needed to combine with the carbon alone. Whether titanium in excess produces similar intermetallic phases is at present under investigation in my laboratory. The most important deduction to be drawn is that better results will be obtained with some columbium-bearing steels with less columbium for a given carbon content, thereby saving the rare element and improving the performance of the component. In some steels, it is desirable to reduce the silicon content as well to below 0.25%.

Recent British work shows that some of the well-known gas-turbine blade steels containing up to 4% Cb would be improved if this content were lowered. The fact that weight-for-weight replacement by some tantalum shows no drop in performance proves this; otherwise the (Cb + Ta) content would need to be increased above 4% total because approximately twice the weight of tantalum is required to replace a given weight of columbium on the likely basis of an atom-to-atom substitution.

It appears that the proper approach to columbium conservation

might well be along the following lines:

1. To use titanium-stabilized steels wherever possible.

2. To examine critically the present steels containing columbium and to reduce the rare element content, with likely advantage in some cases.

3. To explore the partial substitution of columbium by tantalum, which is expected to be quite successful for most applications, with the possible exception of critical arc-welded fabrications. (A ratio of 1 Cb to 2 Ta may ultimately be feasible.)

4. To reserve the columbium supplies for those critical materials and applications where an ample case has been proved, if necessary, by fresh observations.

5. To foster "good housekeeping" by tighter regulations governing the segregation and return of scrap that contains columbium and, if necessary, to arrange on a national basis for clippings or turnings to be degreased and remelted into ingot form, either for direct use or for remelting, using high-frequency induction furnaces so that carbon pick-up is obviated.

It would appear useful for attention (Continued on p. 780)

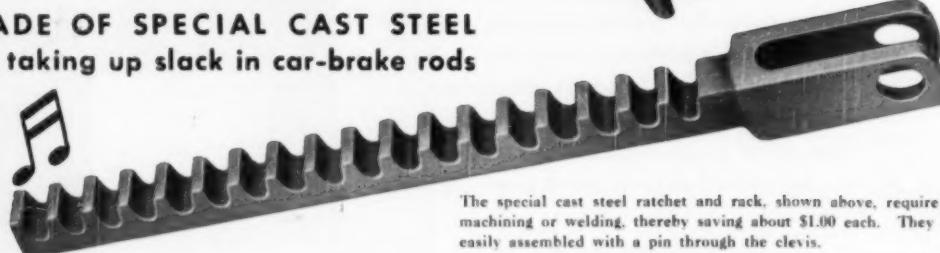
"We've been Working on the Railroad"



RATCHET and
RACK



MADE OF SPECIAL CAST STEEL
for taking up slack in car-brake rods



The special cast steel ratchet and rack, shown above, require no machining or welding, thereby saving about \$1.00 each. They are easily assembled with a pin through the clevis.

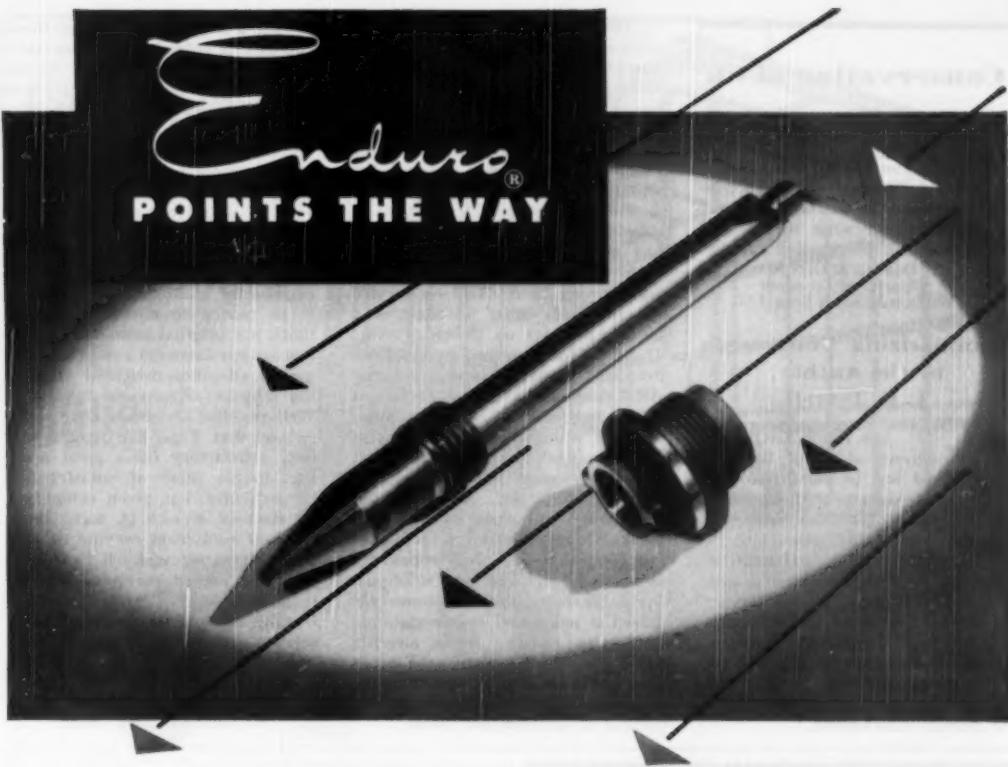
Our plant has made a lot of these and similar items, with highly satisfactory results. Manufacturers prefer the cast tooth, because it is heavier and stronger than the machined tooth, and therefore gives greater service.

We cast these steel parts so accurately that the teeth mesh without machining—proof of excellent foundry practice.

Refer your steel castings problem to us

CHICAGO STEEL FOUNDRY COMPANY

Kedzie Avenue & 37th Street, Chicago 32, Illinois • Makers of Alloy Steel for Over 40 Years



Machinability plus Corrosion • Resistance

High machinability . . . unsurpassed corrosion-resistance . . . here are two of the many good reasons why it pays to use Republic ENDURO Stainless Steel in Free-Machining analyses.

In this stainless steel needle valve and seat used in oil well flow lines, for example, high machinability is obtained from ENDURO type 420-F bar stock. Corrosive crude oil has little effect upon these parts which would be short-lived if made of carbon steel.

A product of Republic's famed Union Drawn Division, ENDURO Cold-finished Bars are

consistently uniform in accuracy of section, fine surface finish and MACHINABILITY. Add ENDURO's natural sanitation, heat-resistance, high strength and ease of cleaning, and you have *all* the reasons for using them in YOUR PRODUCT.

For further information about ENDURO Stainless Steel Bars—cold finished, hot rolled and wire—write *today*.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.



Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Conservation of Cb

(Discussions start on p. 691)
tion to be focused on these possibilities, and it will be of great interest to note what measure of agreement can be reached rapidly.

DONALD A. OLIVER
Director of Research
William Jessop & Sons, Ltd.

Summarizing Statements by the Author, J. F. Tyrrell

SAN DIEGO, CALIF.

The editors of *Metal Progress* have asked me to summarize the topic "Conservation of Columbium" by citing highlights of the discussion, without commenting individually on the many valuable contributions. In such a summary I would give priority of place to the matter of service performance in specific applications. Many of the commentators have written from this point of view; the sum total of their discussions represents a sufficient basis for definite conclusions.

The broad conclusion is that columbium-bearing alloys can almost always be replaced successfully by alloys containing less columbium or no columbium. Usage of less critical alloys is not only being discussed but is long-standing practice in Britain and is now being widely adopted in the U.S.

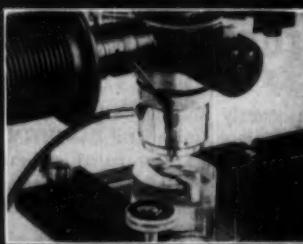
For aircraft components in which columbium-stabilized stainless steel has been found satisfactory, titanium-stabilized steel can be used with no apparent effect on service life and with either no effect or a beneficial effect on productivity. The need for stabilization has been discussed pro and con from the standpoint of selection criteria and service performance. In this summary, I would merely emphasize J. B. Johnson's brief statement that pickling causes embrittlement of unstabilized steels. Aircraft components — particularly in military planes — are cleaned periodically for inspection and weld repair by immersion in strong acid solutions, a routine procedure sometimes required at temporary repair stations. In this exaggerated sense, aircraft parts do "fly through acid solutions", and these solutions do cause intergranular corrosion and embrittlement of unstabilized steels.

Going beyond my original thesis concerning columbium conservation in stainless steel, several British writers have questioned the need for columbium in gas turbine blades and have referred to the successful use of titanium as a hardener in these superalloys. Specific study of such applications might well be considered one of the next tasks because a sudden disruption of shipping schedules could seriously endanger production of jet engines for military aircraft.

In regard to chemical applications, my original article contained a gross misstatement concerning the use of titanium-stabilized steel in the chemical process industries. Well-qualified discussers have pointed out that Type 321 steel is not only satisfactory for a great many uses in the chemical industry but, in particular, has given completely satisfactory service in many items of plant equipment serving in contact with nitric acid. It is well to have the record corrected on this important matter. Also, it is comforting to know of the superior service performance of unstabilized 18-8 with carbon less than 0.03% in chemical process solutions.

On the production side, two
(Continued on p. 782)

mh
micro-
hardness
indenter



versatile, accurate, economical

a precision micro-hardness tester for the metallurgist, mineralogist and research chemist, the mh micro-hardness indenter:

- ◆ attaches interchangeably with objectives of conventional table-type microscopes
- ◆ yields hardness values in terms of STANDARD VICKERS NUMBERS
- ◆ economically converts present microscope to a complete micro-hardness tester
- ◆ employs dead-weight loading (25 to 100 grams); no springs to calibrate, no lever arms to adjust

ERB & GRAY

details on request

specialists
scientific and optical
instruments



854 so. figueroa st.
los angeles 17, calif.



For Fine Metallographic Specimens

This metallographic polisher has three spindles set in a table 28" by 63". The three speed spindles have individual, torque-increasing V-belt drives. The polisher is complete with two faucets and monel wash bowls. Cat. No. 53-474 sells for \$800.00. Request Bulletin 90 showing all models of Eberbach metallographic polishers.

Eberbach
SON COMPANY
DETROIT 10,
UPPER DALE,
SUPPLY
ANN ARBOR, MICH.

Can Your Skeleton Use Tubular Bones?



*Courtesy Cliffside
Body Corporation*

The "bones" in this skeleton are square steel tubes, welded together to make a stiff, rigid frame. The idea, used here to form a truck body, is easily adapted — you may find it profitable.

In this instance, the tubular construction, developed with the help of Frasse specialists, replaced a complicated system of bolted channels, gussets, cross fittings, angles and similar parts. Result? A stronger, more rigid, squeakless body—25% lighter, with more capacity for pay load . . . faster, neater assembly . . . greater flexibility of design . . . and 3 items to inventory instead of 60.

While mechanical tubing is widely used "to save machining the hole", it is equally handy for structural use. It

pays—in product improvement, lower production cost, *often in material cost*, to think of tubing in your product.

And when you think of tubing, think of Frasse. Frasse stocks mechanical tubing, pressure, hydraulic and condenser tubing, stainless tubing—even stainless pipe and fittings. In addition, Frasse maintains a fully qualified engineering department that is always available to assist you in problems involving mechanical steels. Call us. *Peter A. Frasse and Co., Inc., 17 Grand Street, New York 13, N.Y. (Walker 5-2200)* • *3911 Wissabickon Avenue, Philadelphia 29, Pa. (Baldwin 9-9900)* • *50 Exchange Street, Buffalo 3, N.Y. (Washington 2000)* • *Jersey City • Syracuse • Hartford • Rochester • Baltimore*

Send for this FRASSE Tubing Inventory

This handy booklet lists each mechanical tube size immediately available from Frasse warehouse stocks—a useful reference and purchasing guide. Send the coupon for your copy today.

FRASSE
for
Steel Tubing

Seamless and Welded Mechanical Tubing

Condenser and Pressure Tubing • Aircraft Tubing

Stainless Seamless and Welded Tubing • Stainless Pipe and Fittings



PETER A. FRASSE AND CO., INC.
17 Grand Street, New York 13, N.Y.

74K

Please send me a copy of your latest Steel
Tubing Inventory.

Name _____ Title _____

Firm _____

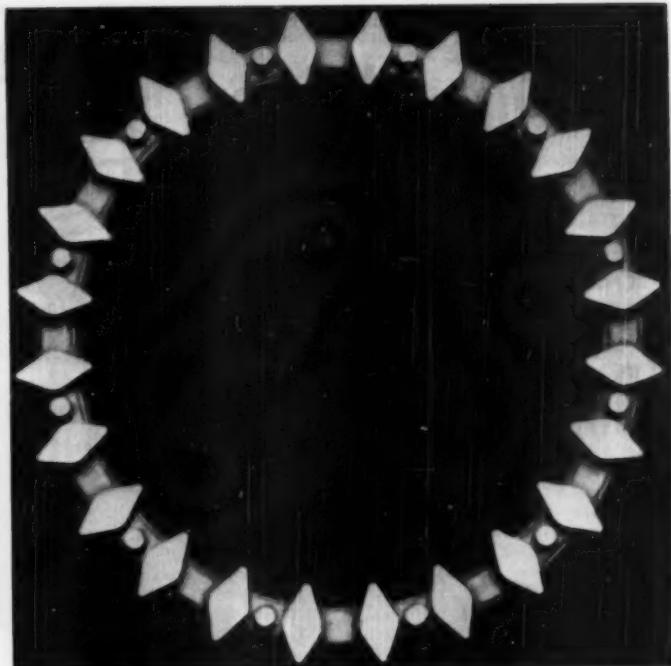
Address _____

Conservation of **Cb**

(Discussions start on p. 691) principal problems have been dealt with in discussion — inclusions in wrought material and melting practice in the foundry. Regarding inclusions, the most hopeful comment has come from D. H. Wiese and H. W. Cooper. I can confirm their statement that much progress has been made in cleaning up the titanium-stabilized steel. During the last two years, Solar Aircraft metallurgists have frequently found that 321 and 347 can no longer be distinguished by their inclusion contents, as shown by routine metallography on random samples. Prior to about 1948, and especially during the war years, careful microscopic examination would usually indicate whether any given sample was 321 or 347.

The decrease in inclusion content of 321 steel is a credit to the ingot producers. Stainless steel foundries are also making a commendable approach to their production problems, and E. Gregory's

(Continued on p. 784)



Fuel Manifold for the Westinghouse J34 Turbojet Engine. Casting, about 15-in. diameter, made from titanium-stabilized steel

WHY GUESS THE TEMPERATURE ... when you can see it!



THE NEW **PYRO** RADIATION PYROMETER

Tells spot temperatures instantly in heat-treating furnaces, kilns, forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature is indicated on direct-reading dial at a press of the button. Any operator can use it. In two double-ranges for all plant and laboratory needs.

Model No. 1: 1000-1800° F. and 1800-2600° F.

Model No. 2: 1400-2400° F. and 2400-3400° F.

Write for FREE Catalog No. 100.

PYRO OPTICAL PYROMETER

Accurate temperatures at a glance!

Determines temperatures of minute spots, fast moving objects or smallest streams — accurately, rapidly. No correction charts or accessories needed. Easy to operate — weighs only 3 lbs. Special types available to show true spout and pouring temperature of molten metal in open. In 5 temperature ranges. Write for FREE Catalog No. 80.

THE PYROMETER INSTRUMENT COMPANY

New Plant and Laboratory
Bergenfield 8, N. J.



The Right Belt for the Job

BY

ASHWORTH

Correct Furnace Belt selection assures longer life, greater efficiency. Ashworth engineers have the ability to recommend the right type of belt for service of a cyclic nature, from room temperature to 2050° Fahrenheit.



Metal Belts
for the handling
of all materials

WHITE FOR
ILLUSTRATED
CATALOG 47P

ASHWORTH BROS., INC.
METAL PRODUCTS DIV. • WORCESTER, MASS.

Sales Engineers located in Buffalo • Chattanooga • Chicago • Cleveland • Detroit
Los Angeles • New York • Philadelphia • Pittsburgh • Seattle
Canadian Rep., PECKOVER'S LTD. • Toronto • Montreal • Halifax • Winnipeg • Vancouver

Why Pereco Utilizes **GLOBAR** Heating Elements for



NEW HIGH TEMPERATURE HEAT TREATING FURNACE

GLOBAR silicon carbide heating elements meet every requirement for heavy duty heat treating furnace applications. They provide a wide temperature range...uniform work chamber temperatures...fast heating...accurate temperature control...and clean, silent heating for extended service periods. Their rod-type construction is readily adaptable to a variety of furnace designs, providing greater work chamber capacity and simplicity of installation and replacement. Obtain complete information on installation and operating details of GLOBAR non-metallic heating elements. Write Dept. X-110, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

← This Pereco Model FG-7800 heavy-duty heat treating furnace will operate up to 2700°F with an atmosphere of air and up to 2450°F with hydrogen and atmospheres containing hydrogen. Equipped with GLOBAR heating elements, it is rated at 34KW.

GLOBAR Heating Elements BY **CARBORUNDUM**



"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

Conservation of Cb

(Discussions start on p. 691) description of the melting practices used at Edgar Allen & Co., Ltd., should be of specific value to American foundrymen.

Solar Aircraft Co., using induction furnaces, has developed a casting process generally similar to that described by Dr. Gregory. However, to eliminate the excessive dirtiness and low fluidity normally associated with Type 321, Solar has devised modified alloying practices that eliminate most of the detrimental impurities. The process, for which patent is pending, produces an improved casting alloy within the specification range of Type 321 but which is easier to cast than Type 347 and is less subject to the formation of hot tears.

A fuel manifold for the Westinghouse J34 turbojet engine is shown in the illustration on page 782. In previous castings of this part, using Type 347, great difficulty was experienced in attempting to eliminate hot tears, even when temperature

and composition were held to extremely close limits. On the contrary, with Type 321 cast by the Solar process, no hot tears have as yet been encountered, even under adverse pouring conditions. Though a certain amount of fading of the titanium takes place, this can be controlled by adding properly sized ferrotitanium. A representative heat log showing titanium content of samples as a function of time after addition of the ferrotitanium is as follows:

TIME	TI	Y.S.	R.A.	ELONG.
0	*			
3 min.	0.32%			
5	0.45	36,500	43%	49%
7	0.53			
9	0.65	36,500	42	40
11	0.68			
13	0.72	38,000	37	40
15	0.66			
17	0.66			

*0.80% Ti added at one time.

No titanium is recovered from the scrap charge.

One other question of detail deserves final comment: H. Allsop has reasonably suggested that aluminum may have influenced our oxidation test results. Accordingly, we have analyzed our test samples for that element. Although both 321 and 347 showed apparently equal aluminum contents of less than 0.02% (the

limit of sensitivity of wet analysis), spectrographic analyses indicated about twice as much aluminum in 321 as in 347. The difference between spectrographic and chemical results could have been caused by aluminum oxide inclusions, which would not show up in ordinary chemical analysis. In order to resolve this uncertainty, we checked a number of heats of 321 until a sample was found which gave no spectrographic traces of aluminum. This specimen was then tested for oxidation resistance at 1850° F. The results confirmed those presented in the original article.

TO SUMMARIZE: Columbium must be conserved and usually can be conserved by substituting less strategic alloys without adverse effect on service life. The successful substitution of titanium-stabilized steel in severe service in aircraft components and chemical process equipment indicates the desirability of re-evaluating all applications in which columbium-bearing alloys are specified. To paraphrase Mr. Evans' discussion, the working rule should be amended to read, "When in doubt, do not use columbium-bearing alloys".

JOHN F. TYRRELL
Solar Aircraft Co.

Producers of DROP FORGED SHACKLES, CLEVIS NUTS, TURNBUCKLES & EYE BOLTS

LENAPE STAINLESS PRESSURE VESSEL ACCESSORIES



TYPE "R" MANWAY



TYPE "R" NOZZLE WITH COVER



LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 103 WEST CHESTER, PA.

Your prints and specifications will be given our prompt attention. Catalog 9-49 will be sent upon request.

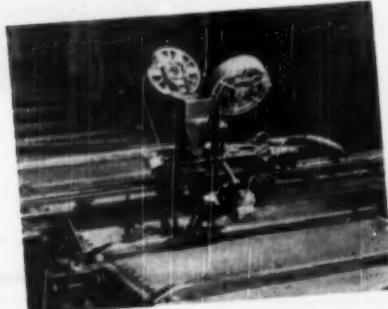
RED MAN PRODUCTS

Ideas on Welded Design—For the Engineer's Notebook

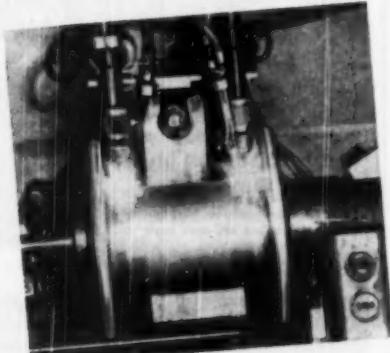
MAKE WELDS SIMULTANEOUSLY

When both ends or both sides of an object must be welded, both welds can often be made simultaneously. Production can thus be doubled — welding time cut in half!

Two UNIONMELT welding heads or two HELIARC torches can often be used — with the weldment turning or moving under stationary welding equipment, or with the welding units moving over the workpiece. Here are examples:



Two UNIONMELT welding heads are simultaneously welding both sides of a stake, joining it to the side panel of a railroad car. The bridge that supports the carriage can be easily shifted for welding both the stakes and diagonal side braces.



Fabrication of aluminum spools is speeded by use of two stationary HELIARC welding torches. The formed ends are joined to the barrel by girth butt welds. The pieces are held together over a backing mandrel, and turned under the HELIARC torches which make both welds simultaneously.

Better design for welding will help cut costs and increase production. For further information, call or write our nearest office.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation
30 E. 47th St., New York 17, N. Y. **UCC** Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto
The terms "Heliarc" and "Unionmelt" are registered trade-marks
of The Linde Air Products Company

Spincraft

"Spinnings Take Many Forms"

All of them
save time
and money

"Spinning," as exemplified by these Spincraft products, is the end result of resourceful thinking . . . for Spincraft engineering has a practical, economical approach to the production of parts that often eliminates the need for expensive dies or machining.

If this saving of time and money is an incentive to you, and you have a part that is round or only in part rounded, check Spincraft before you tool up or reject an idea as too costly. Your inquiry is invited regardless of size or metal — and substantial savings may be your reward.

Spincraft Inc.

4137 W. STATE STREET
MILWAUKEE 8, WISCONSIN

Heretofore known as
Milwaukee Metal Spinning Co.



The new Spincraft data book is yours for the asking — a helpful, fact-full reference bulletin that may accelerate your design ideas.

Spincraft — serving large and small industries everywhere — is the world's largest and most versatile metal spinning plant.



HEAD LAMP RING — a simple circle spun of 16 ga. stainless, 10" dia.



CORONA SHIELD . . . an aluminum spinning combining hemispherical and spherical forms. Made of 250 aluminum, $\frac{1}{8}$ in. thick. Overall length 20 in.



CONICAL ENVELOPE — Spinning for television industry made of $\frac{1}{8}$ in. thick chrome iron — 446 stainless steel — a material previously considered non-formable by any method. The diameter of this tube is 16 in.

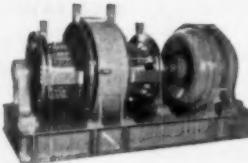


TRANSMISSION HOUSING
Combining a cone and a hemisphere — made of 10 gauge cold rolled steel. The length of this housing is over 30 in.

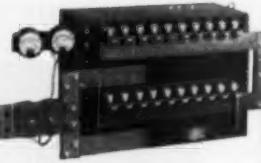
COLUMBIA

MOTOR GENERATORS

for
Electroplating
Anodizing
Electrocleaning
Electropolishing



- TANK RHEOSTATS
- REVERSING SWITCHES
- TONG TEST AMMETERS



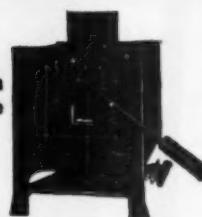
Write for Descriptive Bulletins

COLUMBIA ELECTRIC MFG. CO.
4531 Hamilton Ave. • Cleveland 14, Ohio

"BUZZER" HIGH SPEED Gas FURNACES

2400° F.
attained quickly with
"BUZZER" Full Muffle
Furnaces

Designed primarily for heat treating
high carbon and alloy steels



NO BLOWER or POWER NECESSARY
... just connect to gas supply



"BUZZER" Atmospheric
Pot Hardening Furnaces
assure even heat up to
1650° F.

Used for Salt, Cyanide and Lead
Hardening. Also adapted for
Melting Aluminum.

Send for the complete
"BUZZER" catalog today.

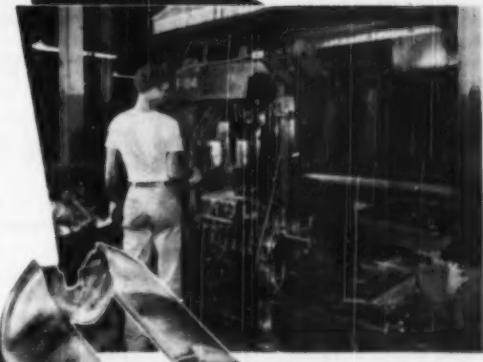
CHARLES A. HONES, INC.

123 So. Grand Ave. Baldwin, L.I., N.Y.



With the foresight and imagination that typifies a progressive company, Speed Queen Corporation of Ripon, Wisconsin, made a careful survey of die casting—and decided to bring the operation under their own roof—using Lester-Phoenix Die Casting Machines!

Here's a case where a company with no previous experience used the economy and efficiency of the Lesters to assure them of successful results. Starting with a battery of six Lester-Phoenix Machines, Speed Queen was soon able to say, "... as to rate of production, we are as good if not better than the average field picture and our quality is excellent." Lester-Phoenix service and engineering personnel will be pleased to help you, too, set up a successful die casting installation in your plant.



Write for your Free Copy of *The Lester Press*

ESTER-PHOENIX DIE CASTING MACHINES

REPRESENTATIVES

New York	Steven F. Krould	Los Angeles	Seaboard Machinery Co.	Toronto, Canada	Modern Tool Works, Ltd.
Baltimore	Thoresen-McCosh	New England	Kavanagh Sales, Inc.	Birmingham, England	Dowding & Duff, Ltd.
Chicago	J. J. Schmidt	San Francisco	J. Fraser Rae	Calcutta, India	Francis Klein & Co., Ltd.
Cleveland	Don Williams	St. Louis, Milwaukee	A. B. Geers	Sydney, Australia	Scott & Holladay, Ltd.
Cincinnati	Index Machinery Corp.			Japan, New York	W. M. Howitt, Inc.

distributed by LESTER-PHOENIX, INC., 2619 CHURCH AVENUE • CLEVELAND 13, OHIO

FOREIGN

METAL PROGRESS

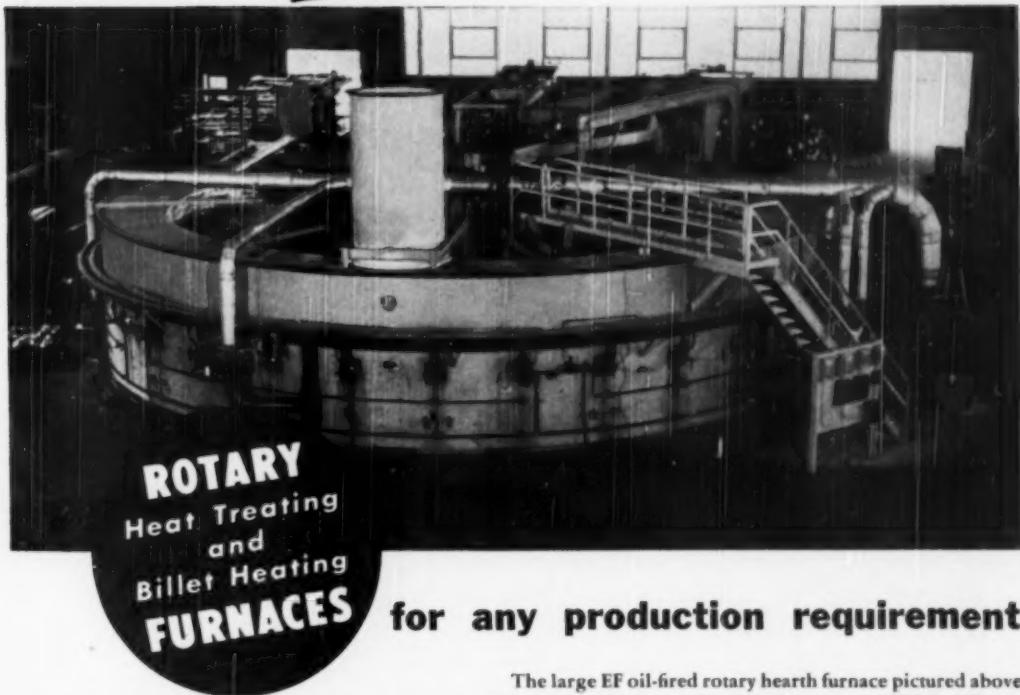
PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

A. P. FORD, Advertising Manager; GEORGE H. LOUGHNER, Production Manager
7301 Euclid Ave., Cleveland 3—UTah 1-8200
ROBERT S. MULLER, Eastern Manager
55 W. 42nd St., New York 18—CHIChering 4-2713
GEORGE P. DRAKE, Mid-Western Manager
184 Park Rd., Park Forest, Illinois—Phone: Chicago Heights 5877-J
DON HARWAY, Pacific Coast, 1709 West 8th St., Los Angeles 14—FAirfax 8576

• Index to Advertisers •

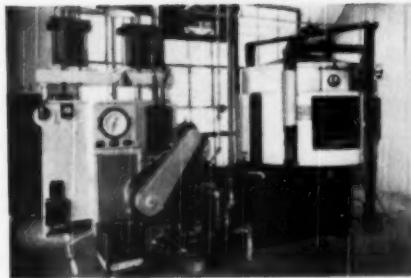
Acheson Colloids Corp.	749	Enthone, Inc.	748	Northwest Chemical Co.	648
Air Reduction Sales Co.	689	Erb & Gray	780	Norton Co.	688
Ajax Electric Co.	783	Finkl & Sons Co., A.	648	Ohio Crankshaft Co.	683
Ajax Electrothermic Corp.	657	Frasse & Co., Peter A.	781	Ohio Ferro-Alloys Corp.	664
Allied Research Products, Inc.	680	General Alloys Co.	773	Ohio Nut & Bolt Co.	764
Alloy Casting Co.	646	General Cerium Co.	764	Ohio Steel Foundry Co.	768
Alloy Precision Castings Co.	762	Gordon Co., Claud S.	760, 766	Pangborn Corp.	768
American Chemical Paint Co.	340	Gray Iron Founders' Society, Inc.	676	Park Chemical Co.	728C
American Gas Furnace Co.	736	Great Lakes Steel Corp.	681	Precision Scientific Co.	769
American Optical Co.	670	Gulf Oil Corp.	671	Pressed Steel Co.	642
American Society for Metals	641, 772, 776	Hevi Duty Electric Co.	684	Pyrometer Instrument Co.	782
Ashworth Brothers, Inc.	782	Holcroft & Co.	784	Republic Steel Corp.	779
Austenal Laboratories, Inc.	647	Hones, Inc., Chas. A.	786	Revere Copper & Brass, Inc.	739
Baker & Adamson Products, General Chemical Div.		Hoskins Mfg. Co.	789	Riverside Metal Co.	681
Allied Chemical & Dye Corp.	707	Houghton & Co., E. F.	672B	Rockwell Co., W. S.	762
Baldwin Locomotive Works	778	Illinois Testing Laboratories	772	Rocklock, Inc.	679
Barrett Div., Allied Chemical & Dye Corp.	748	Inland Steel Co.	690	St. Joseph Lead Co.	680
Bausch & Lomb Optical Co.	729D	International Nickel Co., Inc.	728A, 748	Sentry Co.	738
Bell & Gossett Co.	682	Jarrell-Ash Co.	788	Sharon Steel Corp.	683
Bethlehem Steel Co.	687, 686	Johns-Manville	672A	Solvents & Chemicals Group	768
Buehler, Ltd.	686	Jones & Laughlin Steel Corp.	682	Spencer Turbine Co.	683
Burrell Corp.	782	Kemp Mfg. Co., C. M.	672	SpinCraft, Inc.	786
Carborundum Co.	686A-686B, 783	Korn, Inc., William	774	Steel City Testing Machines, Inc.	760
Carlson, Inc., G. O.	742	Lakeside Steel Improvement Co.	788	Stuart Oil Co., D. A.	780
Carpenter Steel Co.	688	LaSalle Steel Co.	771	Sunbeam Stewart Industrial Furnace Div.	678
Cerium Metals Corp.	786	Leeds & Northrup Co.	643	Surface Combustion Corp., Inside Front Cover	
Chicago Steel Foundry Co.	778	Lenape Hydraulics Pressing & Forging Co.	784		
Cities Service Oil Co.	665	Lester-Phoenix, Inc.	787		
Clark Instrument, Inc.	780	Lindberg Engineering Co.	644		
Climax Molybdenum Co.	782	Linde Air Products Co., Unit of Union Carbide & Carbon Corp.	785		
Columbia Electric Mfg. Co.	786	Merrill Brothers	784		
Columbia Tool Steel Co.	776	Michigan Steel Casting Co.	660		
Copperweld Steel Co.	Back Cover	Minneapolis-Honeywell Regulator Co., (Industrial Div.)	661		
Crucible Steel Co. of America	785	National Carbon Div., Union Carbide & Carbon Corp.	673		
Delaware Tool Steel Corp.	669	National Machinery Co.	662-663		
Driver-Harris Co.	761	National Research Corp.	770		
Dy-Check Co.	668				
Eastman Kodak Co.	741				
Eberbach & Son Co.	788				
Eclipse Fuel Engineering Co.	678				
Electric Furnace Co.	Inside Back Cover				
Electro Alloys Co.	781				
Electro Metallurgical Div., Union Carbide & Carbon Corp.	684				
Engelhard, Inc., Charles	766				
		Westinghouse Electric Corp.	677		
		Wheelco Instruments Co.	777		
		Wheeloock, Lovejoy & Co., Inc.	746		
		Wilson Mechanical Instrument Co.	744		
		Wisconsin Steel Co.	787		
		Youngstown Sheet & Tube Co.	674		

EF builds a size and type of furnace for
every process, product or production



ROTARY
Heat Treating
and
Billet Heating
FURNACES

for any production requirement



The EF "Pan-Dumping" Rotary Furnace pictured above heat treats 250 lbs. per hour of bolts, screws, springs and other small parts economically and uniformly. Furnished complete with Quench Tank, Atmosphere Generator and Automatic Controls.

The large EF oil-fired rotary hearth furnace pictured above is 40 ft. in diameter—heats billets up to 10" by 32" uniformly and efficiently. It has capacity to handle 35,000 lbs. of billets per hour and is equipped with a push-button controlled, hydraulically operated charging and discharging mechanism.

Other EF rotary furnaces, with capacities ranging from 175 to 35,000 lbs. per hour, are used for scale-free heat treating, brazing, billet heating, heating for forging, rolling, extrusion and other ferrous and non-ferrous heat treating operations.

We build all types of batch and continuous furnaces. For maximum efficiency and economy consult the EF engineers on your next furnace job.



and Electric Furnaces

for any Process, Product or Production

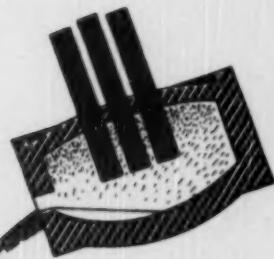
THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R.

Salem - Ohio

ARISTOLOY STEELS

HIT THE MARK



every heat is fully
assured and checked
both chemically and
metallurgically by
laboratory



ARISTOLOY
STEELS

●
STANDARD STRUCTURAL ALLOY
BEARING QUALITY • ALLOY TOOL
SPECIALTY • NITRALLOY
CARBON TOOL • STAINLESS
MAGNAFLUX — AIRCRAFT QUALITY

COPPERWELD STEEL COMPANY, WARREN, OHIO

117 Liberty Street
New York, New York

176 W. Adams Street
Chicago, Illinois

P. O. Box 1633
Tulsa, Oklahoma

1578 Union Commerce Building
Cleveland, Ohio

7251 General Motors Building
Detroit, Michigan

403 W. Eighth Street
Los Angeles 14, California

528 Fisher Building
Detroit, Michigan

3104 Smith Tower
Seattle, Washington

Mondaneck Building
San Francisco 5, Calif.